Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

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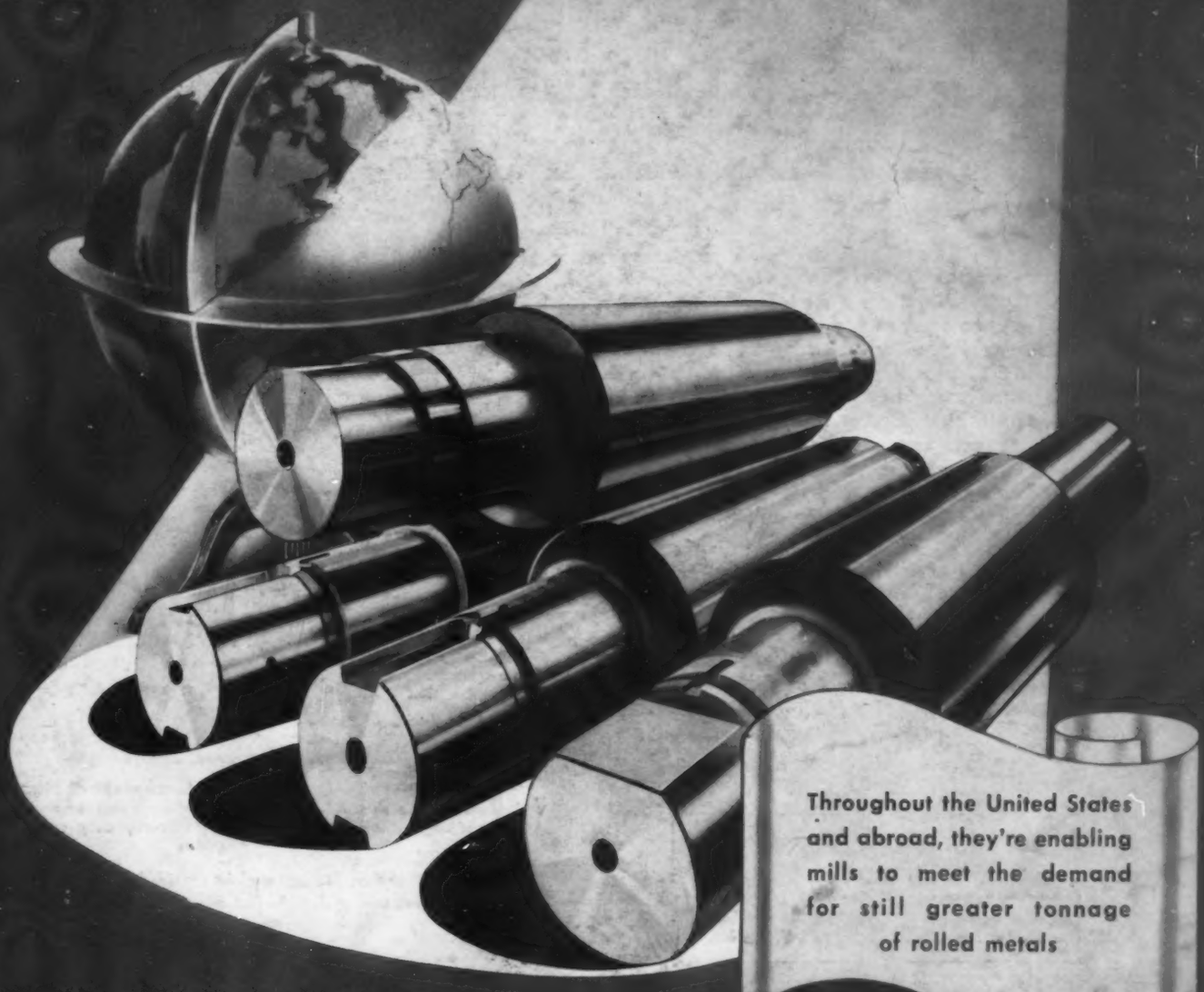
LEWIS ROLLS



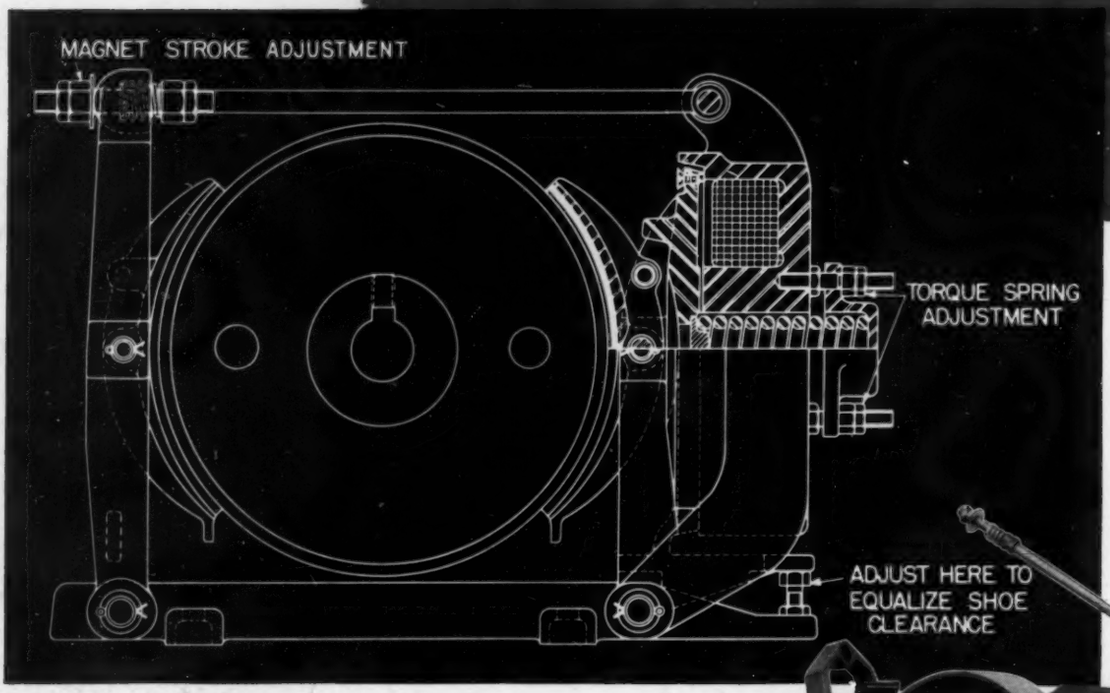
Throughout the United States and abroad, they're enabling mills to meet the demand for still greater tonnage of rolled metals

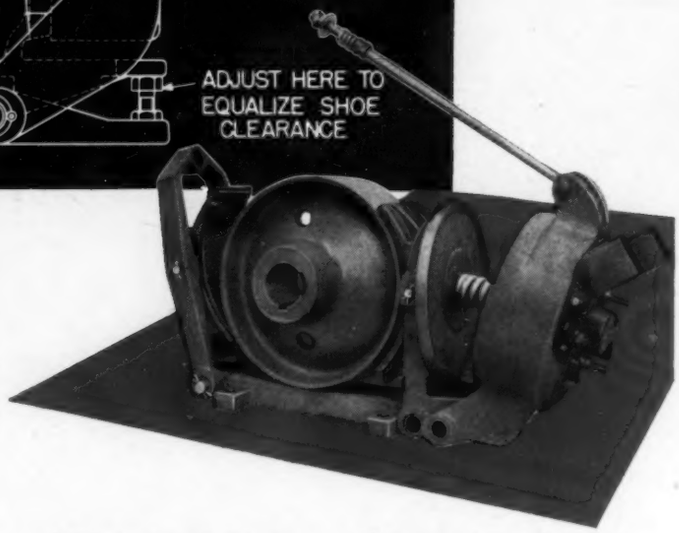
LEWIS FOUNDRY & MACHINE
DIVISION OF BLAW-KNOX COMPANY, PITTSBURGH, PA.

ALSO MANUFACTURERS OF
ROLLING MILL MACHINERY
FOR THE IRON, STEEL AND
NON-FERROUS
INDUSTRIES

A Feature-by-Feature Check

SHOWS WHY THE C-H TYPE M IS THE LONG LIFE LOW MAINTENANCE MILL TYPE D.C. BRAKE





The Cutler-Hammer Type M Brake is the simplest of all mill-type brakes since its action is a direct push of the shoe against the brake wheel by the armature member and a direct pull of the other shoe by the field member. Braking action and release are thus particularly fast. The simple design eliminates parts that get out of order and need repair. The magnet stroke is the same as the total shoe stroke and with the extra long-wearing brake lining and absence of toggles, bell cranks and levers, take-up adjustments are needed only at unusually long intervals. "This is the brake that gives no trouble," say many maintenance supervisors.

14 fundamental facts demonstrate clearly this brake has no equal in dependability, and durability . . . as shown clearly in the new Cutler-Hammer Publication BR-2. Write for a copy today. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin. Associate: Canadian Cutler-Hammer, Ltd., Toronto, Ont.

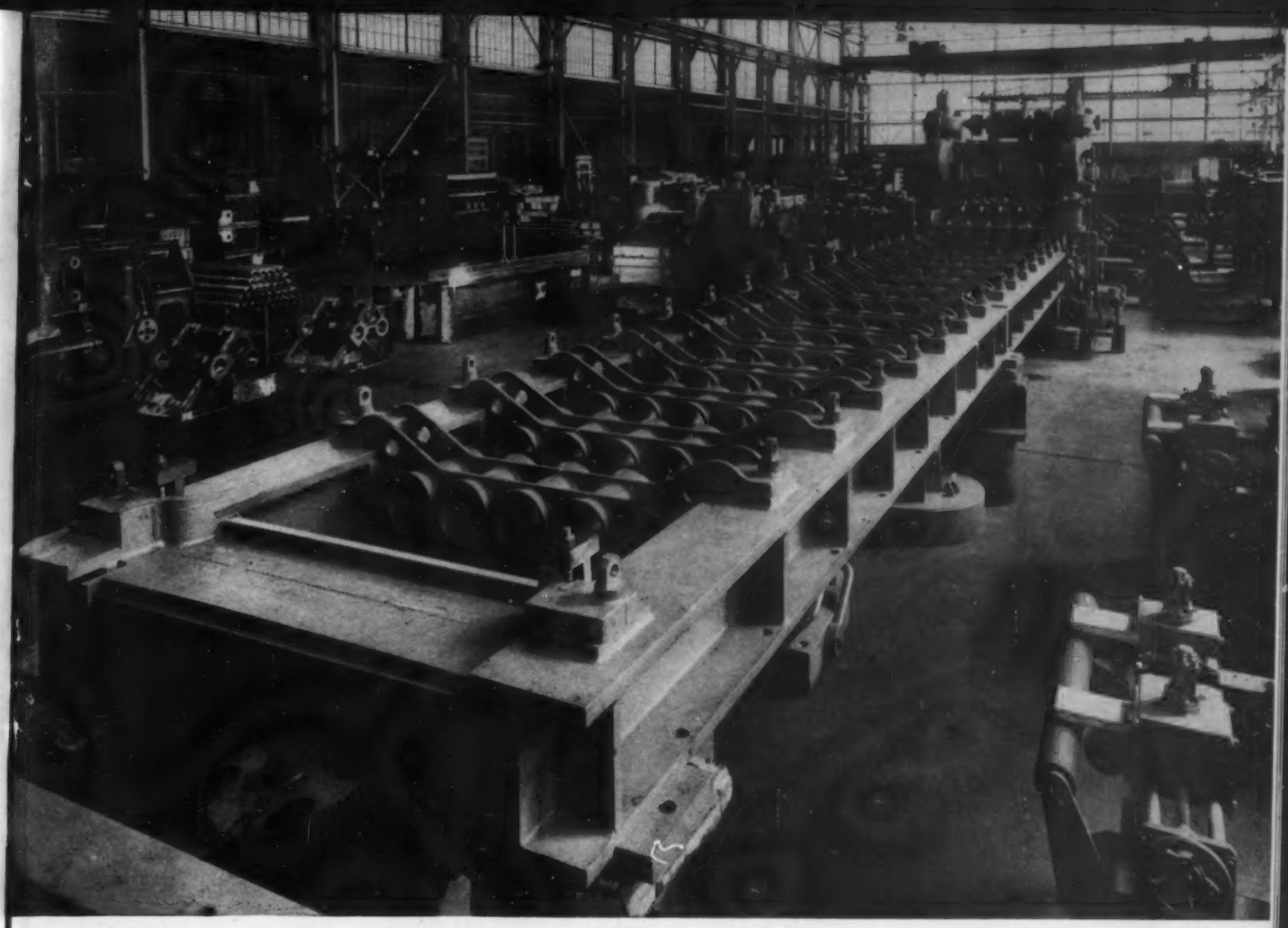
- √ **The simplest of all brakes**
- √ **The brake with the fastest action**
- √ **The *only* brake with one-to-one magnet and total shoe stroke**
- √ **Tough long-life lining matched with hard Hammerloy steel wheel**
- √ **Has the *fewest* parts**
- √ **The brake with *only* 3 simple adjustments**
- √ **Longest service without take-up adjustments**
- √ **Cover-all tubes shield *full length* of hinge pins against corrosion**
- √ **Renewable hardened hinge pin bushings**
- √ **Brass magnet coil cover plate caulked in place with babbitt wire**
- √ **Torque spring compression *CANNOT* be released manually**
- √ **Torque spring fully protected**
- √ **Brass friction plugs keep shoes always aligned**
- √ **Fundamental design proved by years of service in heavy duty applications**

All of these features are also provided, when used on A. C. Service with rectifier

CUTLER-HAMMER
MOTOR CONTROL
C-H

It Set the Pattern Years Ago
It has Set the Pace Ever Since

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress March 3, 1879. $7.50 per year in United States, $8.25 Canada, $10.00 foreign countries. Volume 24, No. 12.



Here is the plug mill unit for the new Aetna-Standard 5-1/2" seamless tube mill.

another seamless tube mill by . . .

Aetna-Standard

AETNA-STANDARD HAS BUILT MORE SEAMLESS TUBE MILLS THAN ANY OTHER COMPANY

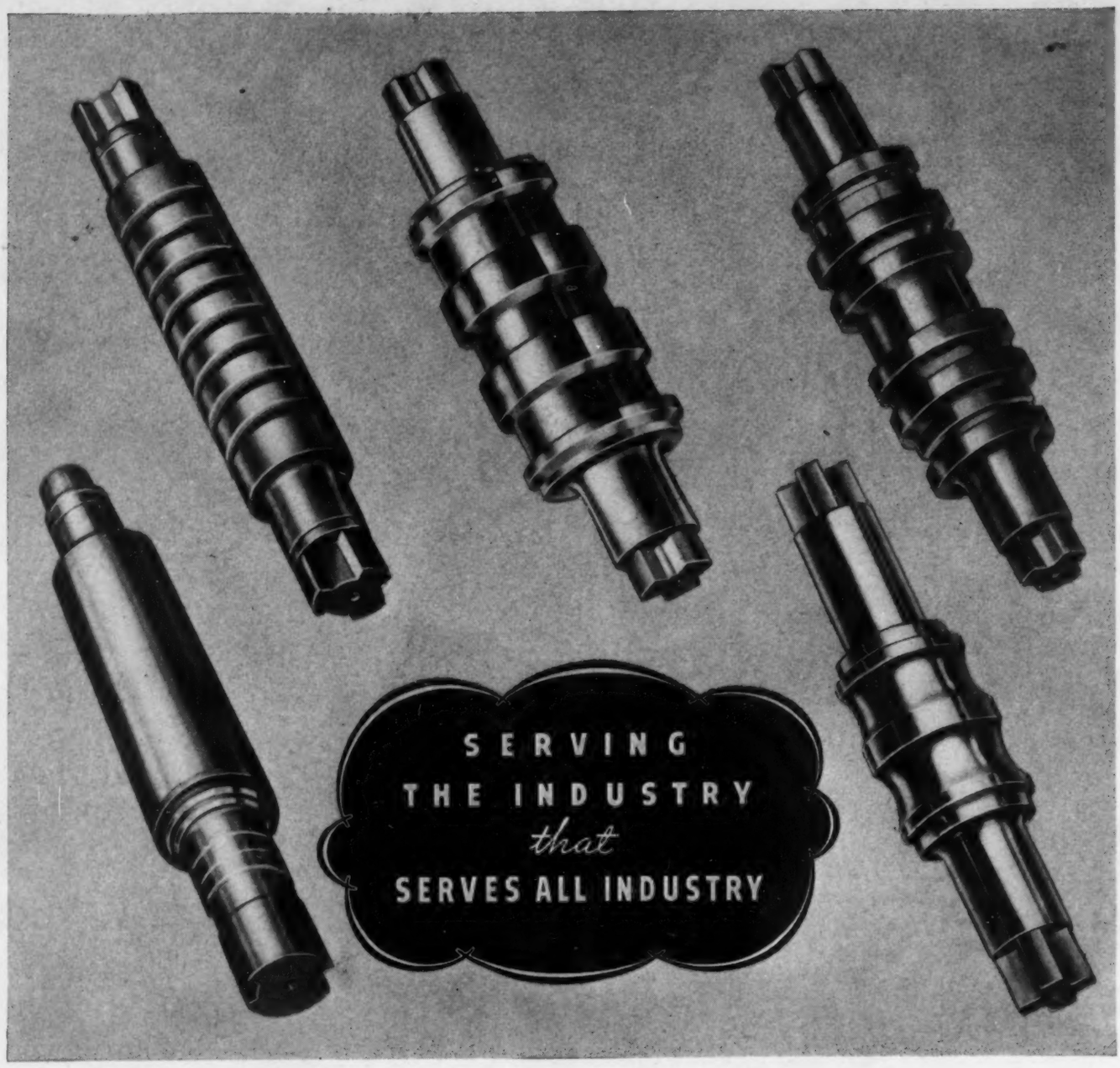
- *This newest seamless tube mill has a range up to 5-1/2" O. D.*
- Builders of more seamless tube mills than any other company, Aetna-Standard engineered this latest mill *complete,* including foundation drawings and electrical specifications. All units, from billet yard to finishing equipment, are being fabricated in Aetna's plants at Ellwood City, Pa., and Warren, Ohio.
- In addition to this 5-1/2" mill, Aetna-Standard is also completing two other seamless tube mills . . . fastest in the world.
- This company manufactures most of the world's seamless tube mills, and also makes continuous butt weld pipe mills, rolls, auxiliary items and many other mill equipment products.

DESIGNERS AND BUILDERS to the Steel, Non-Ferrous and Chemical Industries

THE AETNA-STANDARD ENGINEERING COMPANY

YOUNGSTOWN, OHIO

ASSOCIATED COMPANY: HEAD WRIGHTSON & COMPANY, LTD., MIDDLESBROUGH, ENGLAND



Serving the steel industry with iron and alloy iron rolls has been a specialized endeavor with National since 1909. We pour and turn them with a specialist's eye for perfection; with the specialist's pride in his work.

Our facilities are the most modern, and our people have the highly necessary background of experience. But most important we have the *will* to give you real roll service. Just try us and see.

National Rolls

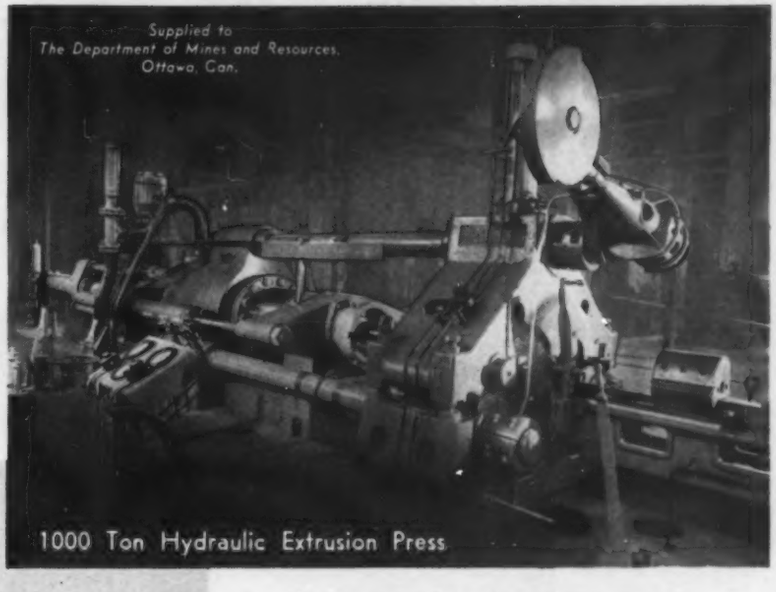
THE NATIONAL ROLL & FOUNDRY CO.

AVONMORE, PENNSYLVANIA

SPECIALISTS IN IRON AND ALLOY IRON ROLLS

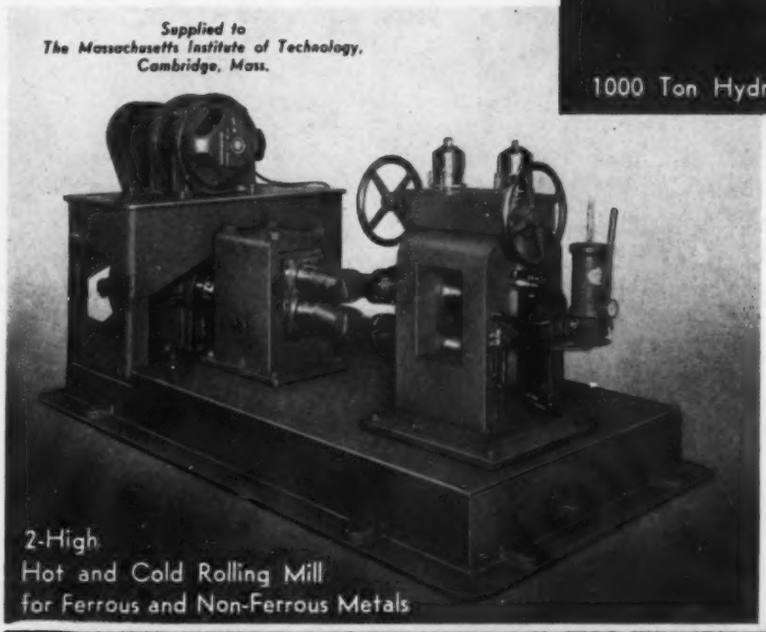
HYDRAULIC MACHINERY AND ROLLING MILLS

FOR RESEARCH AND LABORATORY



Supplied to
The Department of Mines and Resources,
Ottawa, Can.

1000 Ton Hydraulic Extrusion Press



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2-High
Hot and Cold Rolling Mill
for Ferrous and Non-Ferrous Metals

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ROLLING MILLS AND ROLLING MILL EQUIPMENT

for Steel, Ferrous and Non-Ferrous Metals such as Aluminum, Magnesium, Lead, Zinc, Nickel, Brass, Bronze, etc.

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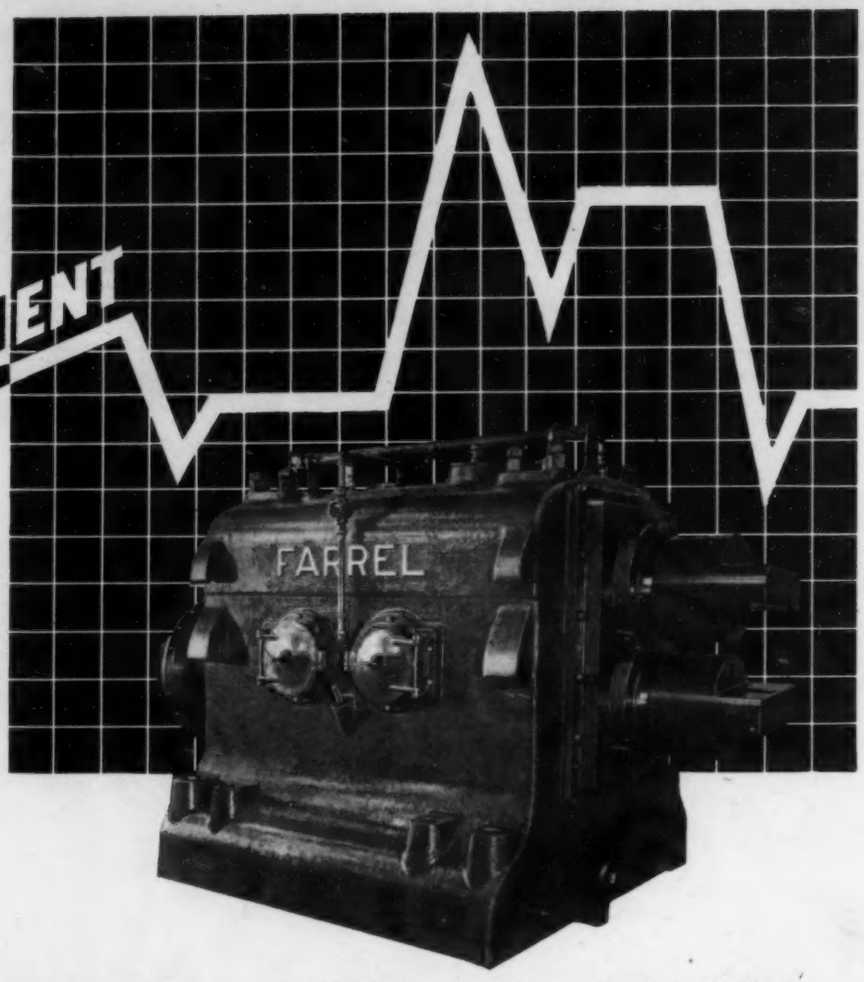
HERE'S why this PINION STAND can take POWER PUNISHMENT



A Farrel pinion stand is built for the specific job it has to do . . . it is prepared and fortified by design to withstand the power shocks and stresses it will get on that job.

This "custom-tailored" protection safeguards power transmission efficiency through long trouble-free years of rugged duty. Every vital part of each unit is of a size and material which provides fully adequate strength to meet continuously the power "punches" and loads to be encountered.

1. HOUSING—Meehanite, cast steel or welded steel construction, designed to bear the brunt of rolling mill service and to maintain accurate alignment of the pinions.
2. BEARINGS — Babbitt-lined, steel-backed, sleeve bearings, or any approved make of anti-friction bearings—always amply proportioned for the job.
3. PINIONS — Continuous tooth herringbone, precision generated by the famous Farrel-Sykes process. The fact that the helices meet in sharp apices, instead of being separated by a center groove, provides extra strength and load-carrying capacity.
4. LUBRICATION—By dip-and-splash system, or force-feed by separate motor-driven pump or from centralized lubrication system, depending on conditions or requirements.

Farrel will design and build a pinion stand for your particular application that you can depend on for years of satisfactory service. Information will be supplied on request, and engineering help is available, if desired.

FB-338

FARREL ROLLING MILL MACHINERY

Rolls	Mill Pinions
Rolling Mills	Pinion Stands
Rod Mill Tables and Manipulating Equipment	Gear Drives of any Capacity
Universal Mill Spindles	Flexible Couplings
Rod Coilers	Roll Grinding Machines
Gears	Roll Calipers
	Lead Presses for Pipe or Rod

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.

Plants: Ansonia and Derby, Connecticut, Buffalo, New York
Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Chicago, Los Angeles, Tulsa, Houston

Farrel-Birmingham

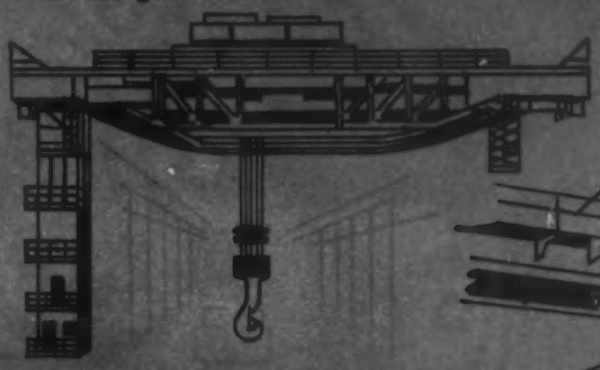
World's Largest Builder of the World's Largest Cranes

Alliance

Alliance makes the equipment to move slabs, ingots, hot metal, raw material and finished products safely, quickly, and easily.

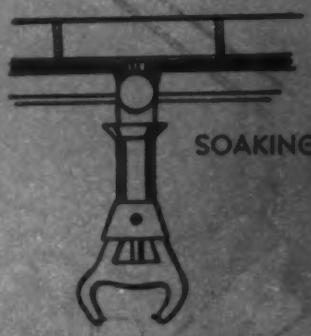
For 50-odd years, Alliance has been known as The World's Largest Builders of the World's Largest Cranes.

GANTRY CRANE



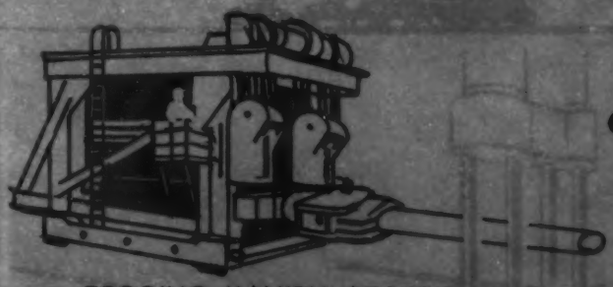
LADLE CRANE

STRIPPER CRANE

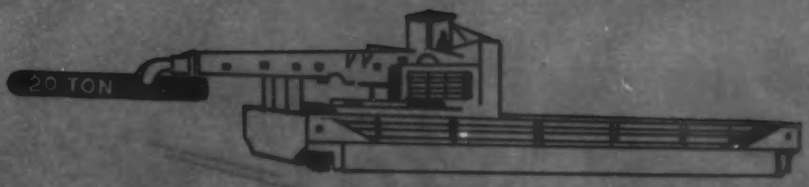


SOAKING PIT CRANE

OPEN HEARTH CHARGING MACHINE



FORGING MANIPULATORS



SLAB AND BILLET CHARGING MACHINE

THE ALLIANCE MACHINE COMPANY

ALLIANCE, OHIO · 1622 OLIVER BLDG., PITTSBURGH, PA.

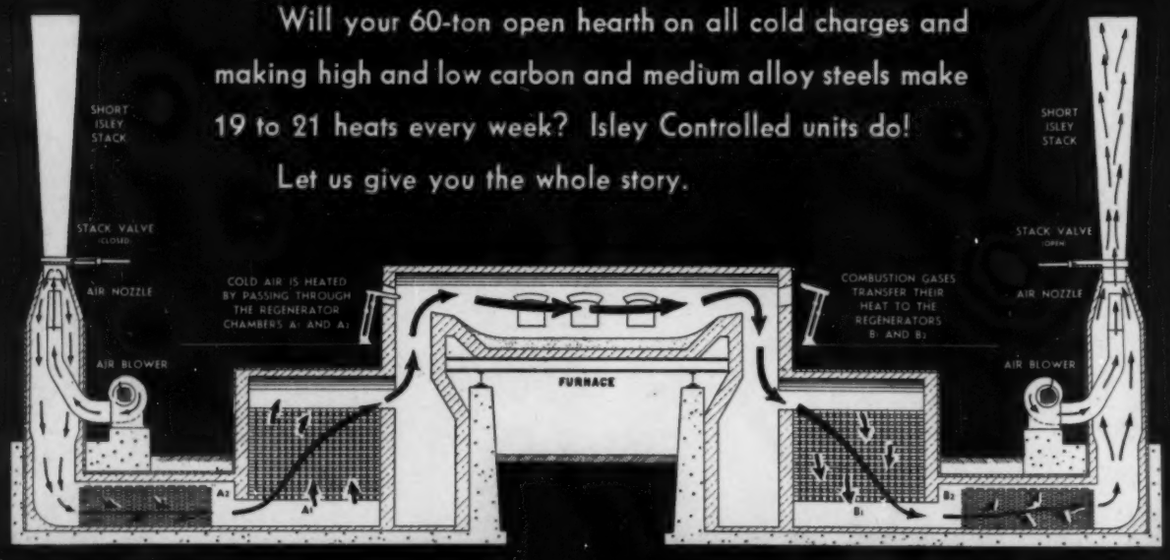
SPEED UP YOUR FURNACES

with the ISLEY SYSTEM of FURNACE CONTROL

You can get more production from your regenerative furnaces. Equip them with the Isley Control System. It gives up to 50% more regenerative capacity . . . gets more fuel burned per hour . . . produces faster heats with higher furnace temperatures.

Will your 60-ton open hearth on all cold charges and making high and low carbon and medium alloy steels make 19 to 21 heats every week? Isley Controlled units do!

Let us give you the whole story.



MORGAN CONSTRUCTION COMPANY

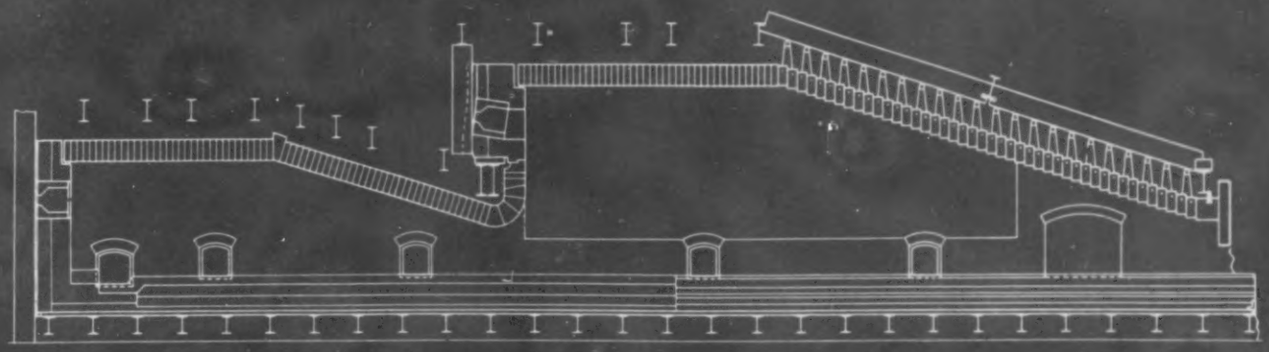
WORCESTER, MASSACHUSETTS

CCC-11

PITTSBURGH, PA., 2815 Koppers Building

English Representative, International Construction Company, 55 Kingsway, London W. C. 2, England

How B&W REFRACTORIES *Lead to Lower Production Costs Under Severe Furnace Conditions*



B&W Refractories used in the construction of this furnace include:

B&W Insulating Firebrick
B&W Junior Firebrick
B&W Plastic Chrome Ore
B&W Light-Weight Insulating Concrete Mix
B&W Smoothset Mortar

In 1942 this gas-fired slab-heating furnace, lined with B&W Refractories, went into service. Through the rigorous war years, and the years that have followed, it has been operating continuously—day and night—often at 10 to 20 per cent over capacity and at high temperatures.

During a recent inspection, it was found that the B&W Refractories were in such excellent condition that long additional service life was predicted.

Increasing production through greater furnace availability, and eliminating excessive maintenance are just two of the many ways in which B&W Refractories are helping to cut production costs for industry throughout the country. Your local B&W Refractories Engineer will be glad to show you how they can benefit you.

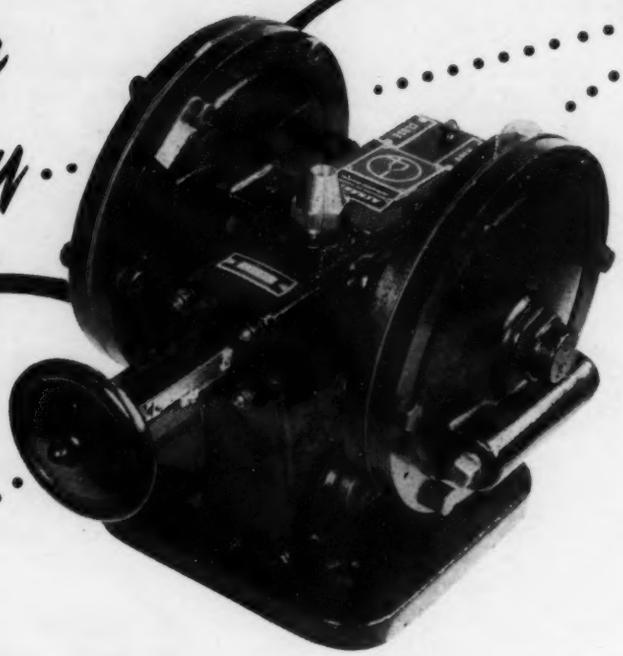
R-289

Water-Tube Boilers, for Stationary Power Plants, for Marine Service . . . Water-Cooled Furnaces . . . Superheaters . . . Economizers . . . Air Heaters . . . Pulverized-Coal Equipment . . . Chain-Grate Stokers . . . Oil, Gas and Multifuel Burners . . . Seamless and Welded Tubes and Pipe . . . Refractories . . . Process Equipment.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
WORKS: AUGUSTA, GA.

FOR CONTINUOUS AUTOMATIC PROPORTIONING WITH *Maximum Accuracy*..



THE ASKANIA RATIO REGULATOR

A simple, accurate way of mixing two or more liquids or gases to a predetermined ratio. Ratio can be changed easily without interruption of the process. • The Askania Ratio Regulator has only a few moving parts reducing maintenance to a minimum. • Low pressure systems use Fiberglas Diaphragms, measuring changes in conditions as small as .0025" W.C. • Turn down range of 10 to 1, with accuracy across full range. For control of fuel/air mixtures, for mixing propane-butane and natural gas, for processing change from batch to continuous mixing...for proportioning two or more gases, liquids or gases with liquids...use the Askania Ratio Regulator.

for detailed data get Technical Bulletin No. 101

OTHER ASKANIA EQUIPMENT AVAILABLE FOR THE ACCURATE CONTROL OF FLOW, PRESSURE, SPEED AND CONSISTENCY

ASKANIA Controls

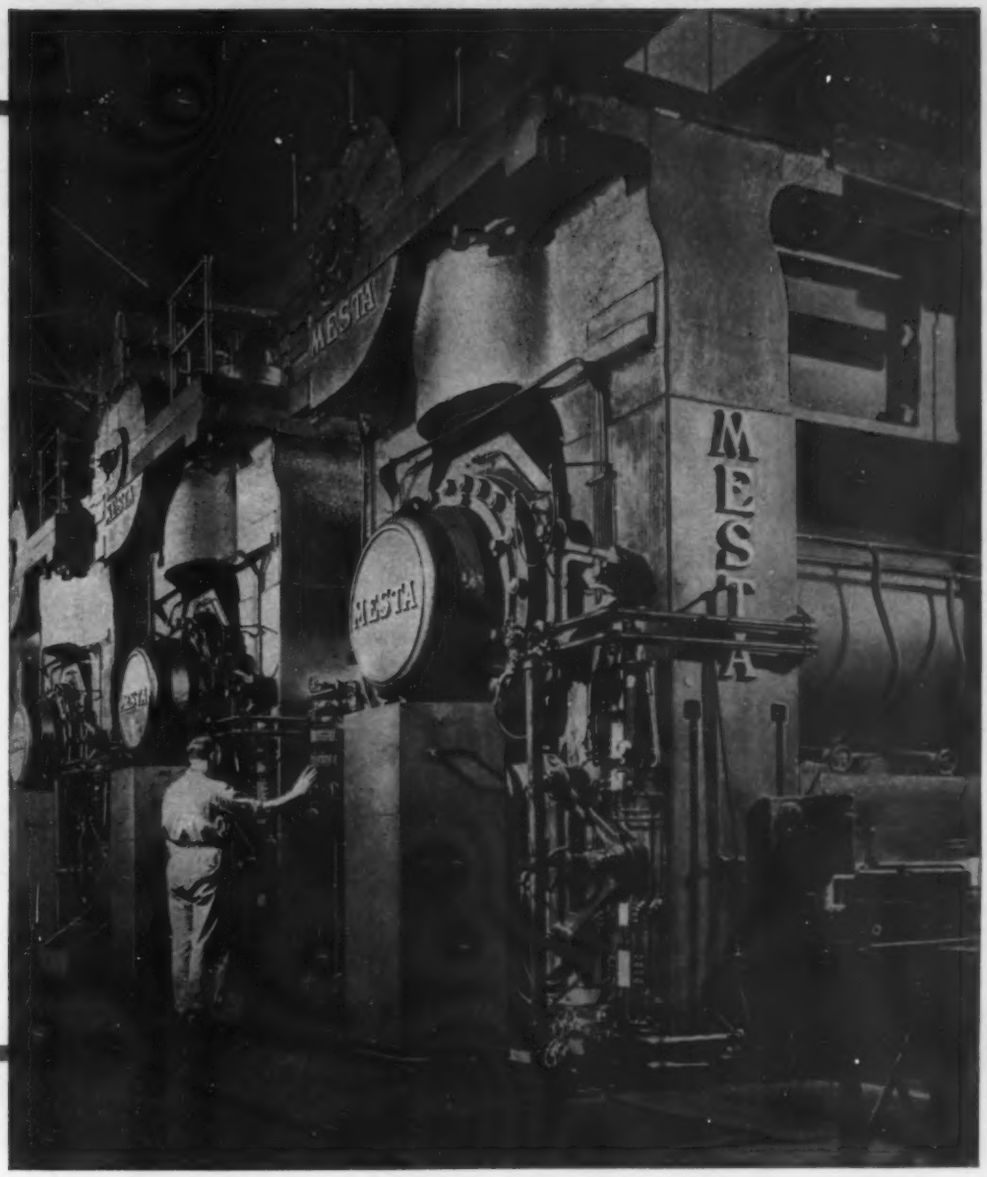
ASKANIA REGULATOR COMPANY

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

240 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

EXPORT OFFICE FOR LATIN AMERICA: 44 WHITEHALL ST., NEW YORK, N. Y.

KEEP ROLL NECKS ROLLING



TEXACO REGAL OILS are heavy-duty, turbine-grade circulating oils. They stand up under high speeds and temperatures . . . carry heavy loads easily . . . resist oxidation, emulsification and sludging. *Texaco Regal Oils* thus keep the circulating system clean . . . bearings fully protected with a constant flow of cool, clean oil. They are your best bet to assure continuous production without expensive bearing maintenance.

Protect your heavy-duty enclosed gears (including worms) with *Texaco Meropa Lubricants.* Their load-carrying capacity is more than ample for any shock loads or pressures.

A Texaco Lubrication Engineer will gladly work with you. Just call the nearest of the more than 2500 Texaco distributing plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, New York.

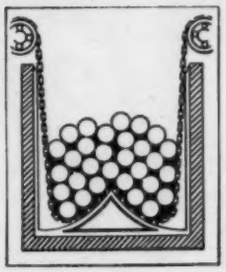
TEXACO

TEXACO Regal Oils

(HEAVY DUTY CIRCULATING OILS)

TUNE IN . . . TEXACO STAR THEATRE presents the TONY MARTIN SHOW every Sunday night. • METROPOLITAN OPERA broadcasts every Saturday afternoon.

A "Sweet" Pickler



MONEL CHAINS *in the Weldco mechanical pickler move up and down alternately, revolving stock and exposing all surfaces. At left, Monel "spreader" which helps revolve load, crack oxide scale and increase agitation. Sprockets, chain, and tank trim are also Monel. (Fabricated by* Youngstown Welding & Engineering Company, Youngstown, O.)

● You've seen mechanical picklers before.

But have you come across one with all the features of this *Weldco* job?

Developed by the YOUNGSTOWN WELDING AND ENGINEERING COMPANY, Youngstown, Ohio, it handles everything from bars, flats and tubes to rounds, squares and hexagons. Automatically raises and lowers up to 10-ton loads at whatever speed you set. Cuts pickling time as much as 40 to 60 per cent.

Yet that's only the beginning. The *Weldco* mechanical pickler saves steam, acid, labor and maintenance besides.

Take the "spreader," a device that breaks up the load and makes it roll. This not only increases agitation, but also helps crack oxide scale. You get *faster* pickling . . . uniform action on *all* surfaces . . . reduce over-pickling . . . save steel.

The spreader — like all exposed parts of Youngstown's Weldco mechanical pickler — is made of Monel*. Experienced pickling room men know the *additional* savings that Monel makes possible.

For Monel withstands attack by hot sulfuric acid and other pickling solutions in common use by steel mills. It retains its high strength and resistance to corrosion. It assures more continuous operation . . . requires less time out for repairs.

You get these advantages, too, when you specify Monel for crates, racks, baskets, hooks, chain and accessories. Whether you measure loads in pounds or tons . . . whether you pickle sheets, tubes or castings, tiny screw machine products or heavy stampings . . . *Monel is the practical, economical metal for the job.*

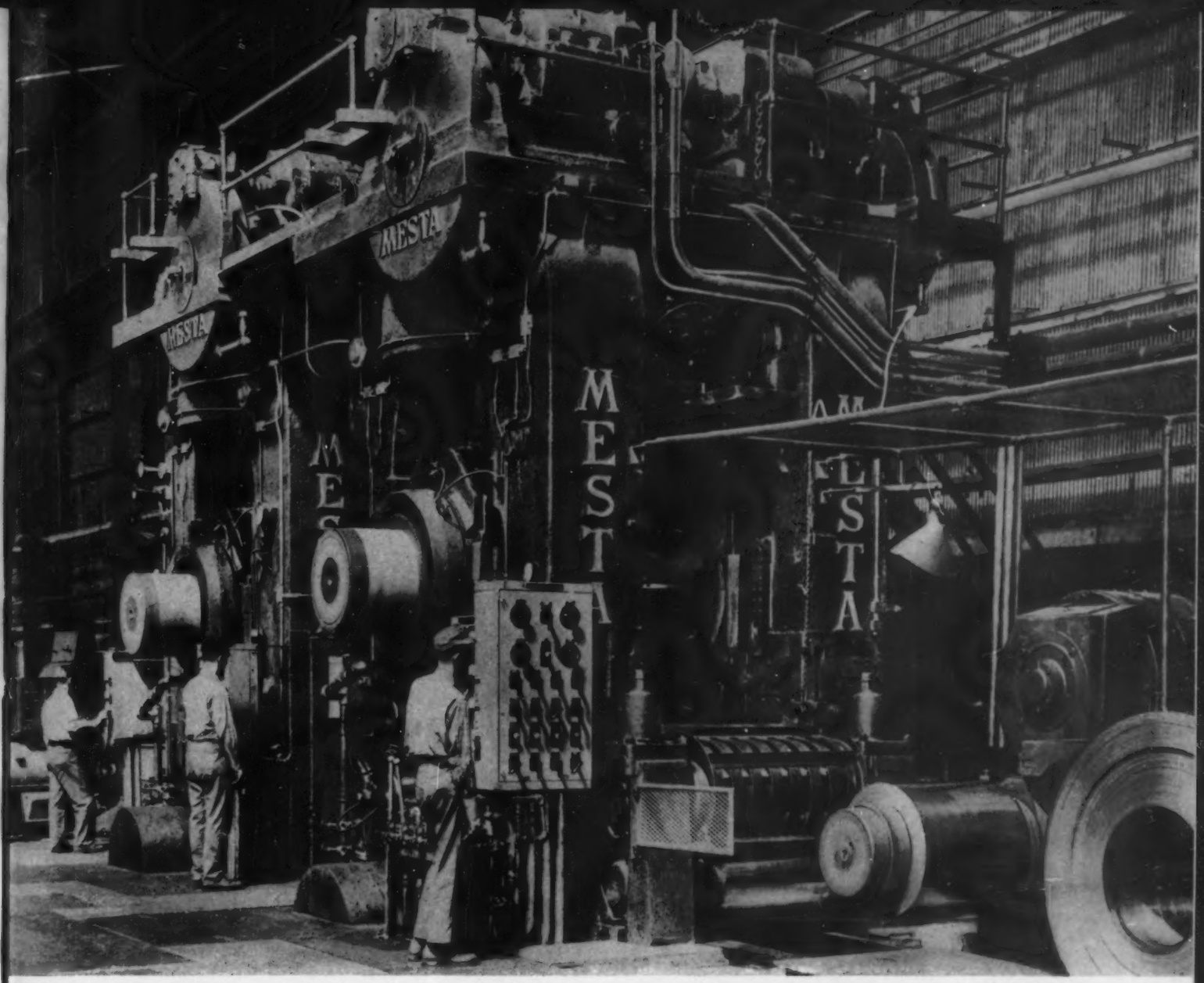
Monel*

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK 5, N. Y.

NICKEL (INCO TRADE MARK) ALLOYS

MONEL* • "K"* MONEL • "S"* MONEL • "R"* MONEL • NICKEL • "KR"* MONEL
INCONEL* • "Z"* NICKEL • "L"* NICKEL

*Reg. U. S. Pat. Off.



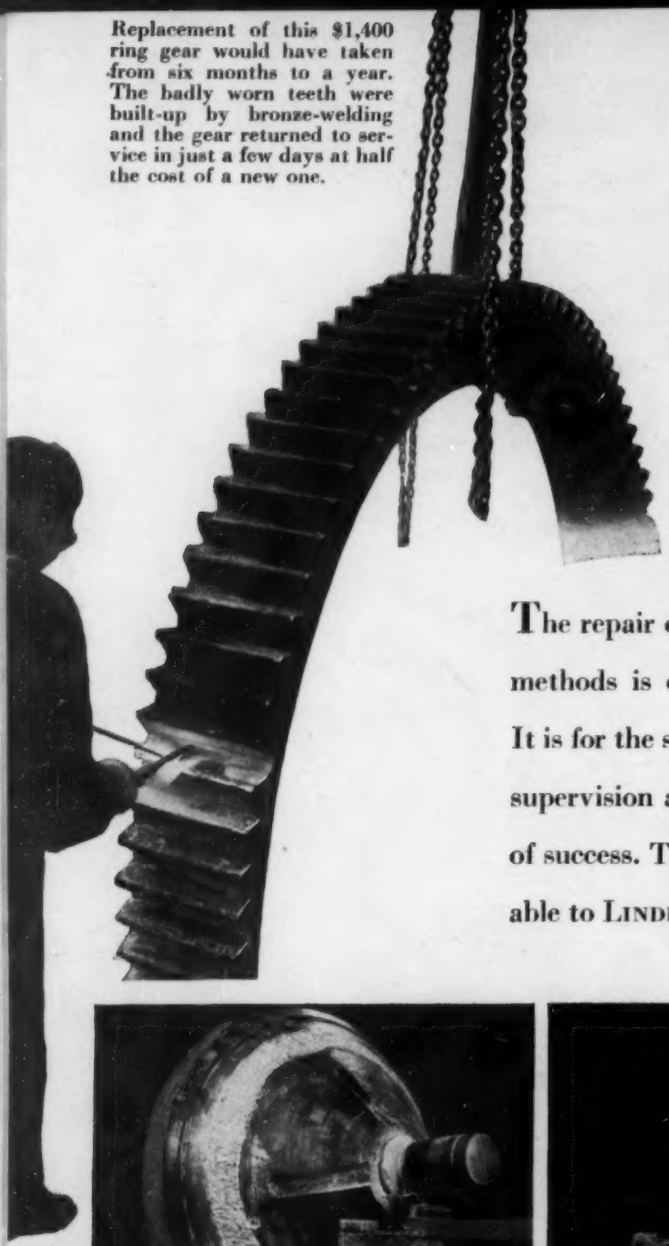
All required tempers can be produced on Mesta High-Speed Twin Four-High Cold Skin Pass Mills. These mills feature new types of drives and control systems which maintain synchronization during acceleration, deceleration, and at normal operating speeds.

MESTA

Cold Mills

DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

MESTA MACHINE COMPANY · PITTSBURGH, PA.



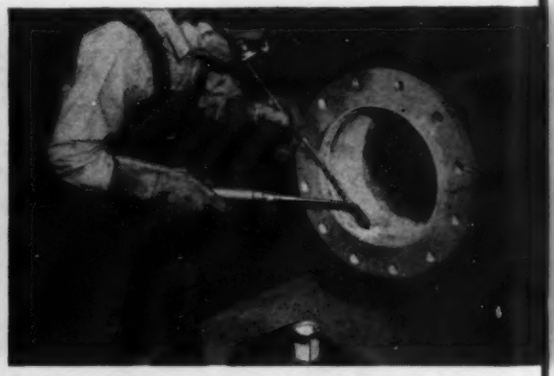
Replacement of this $1,400 ring gear would have taken from six months to a year. The badly worn teeth were built-up by bronze-welding and the gear returned to service in just a few days at half the cost of a new one.

Keeping the "wheels" going 'round

The repair of vast quantities of equipment by oxy-acetylene methods is of course routine for plant maintenance crews. It is for the special job, however, that the LINDE serviceman's supervision and work proves so valuable and gives assurance of success. This skilled, specialized assistance is always available to LINDE customers. Just phone the nearest LINDE office.

Bronze-welding this cast steel cone crusher head saved $1,000. The crack, which ran completely around the head for a distance of 9½ ft., extended through the thickness of the casting in several places. It was veed out by flame-gouging.

This cast iron steam hammer cylinder weighs 4,000 lb. Two large cracks, one on each side of the cylinder wall, were bronze-welded in only 14 hours. A new casting would have taken 16 weeks to obtain and would have cost more than 10 times as much.



Flanges are quickly joined to cast iron pipe sections by bronze-welding. LINDE supplies several bronze rods to meet varying service requirements.

Bronze-welding effected a considerable saving of cost and time when four spokes of this huge cast iron pulp-chipper wheel was cracked at the hub.

Linde

The word "Linde" is a registered trade-mark of The Linde Air Products Company.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 East 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

INDUSTRY

THE PROVING GROUND FOR TURBO BLOWERS

Steel mills... oil refineries... copper smelters... coke plants... mines... foundries... These and other industries are the proving ground for hundreds of I-R blowers... the proving ground of hard, constant, year in and year out service.

On normal jobs and the tough ones these blowers have proven their excellent P-M-A rating. They've done the kind of a job you would expect of a good blower and they've done it at the lowest possible cost.

You will want to give your plant the benefit of the low Power costs, low Maintenance costs and high Availability factor of Ingersoll-Rand turbo blowers.

LOW POWER COST — Money Saved
LOW MAINTENANCE COST — Money Saved
HIGH AVAILABILITY FACTOR — Money Earned
IT ALL ADDS UP!

COMPRESSORS • AIR TOOLS
OIL AND GAS ENGINES
CONDENSERS • CENTRIFUGAL PUMPS

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

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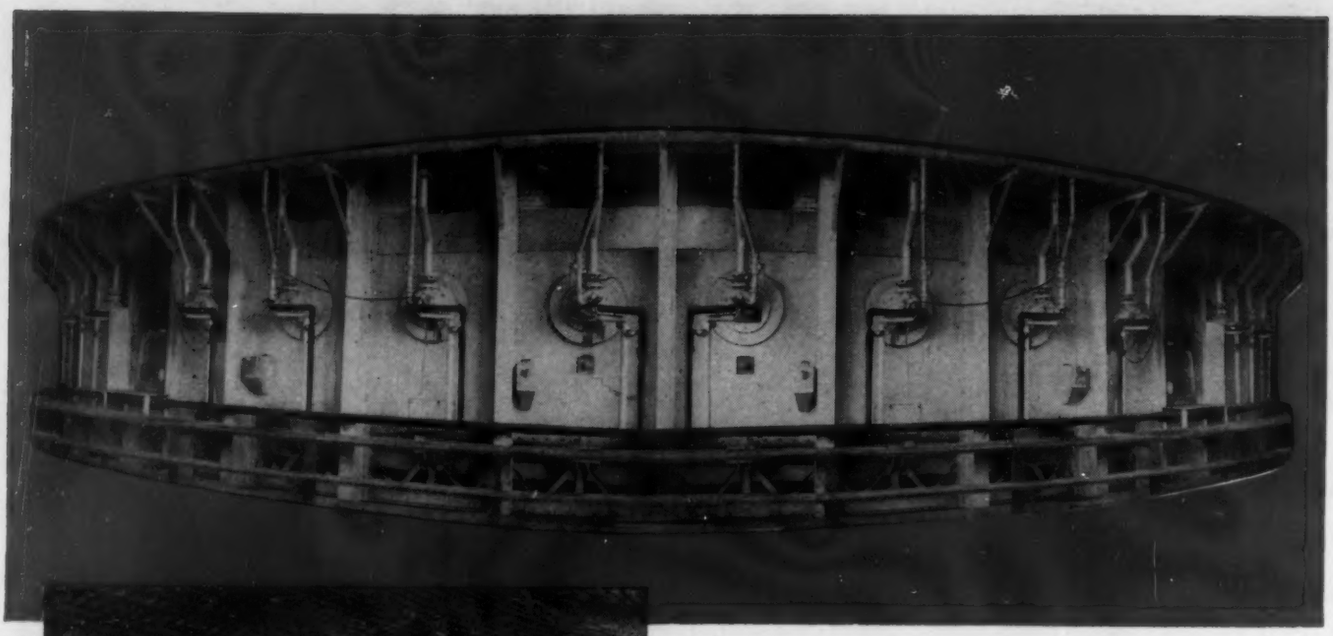
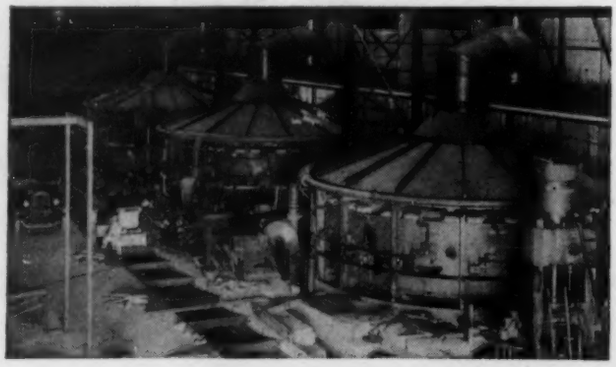


Inside view after five years' service.



SALEM ROTARY FURNACES ARE POPULAR

Good Planning and Engineering result in patented features which combine increased production with easy and low cost maintenance

The seal between the rotating hearth and the stationary walls can be easily lowered in short sections to provide quick and complete accessibility.

This type seal is another of Salem's many patented features, carefully developed to improve equipment.

SALEM ENGINEERING CO. • SALEM, OHIO
SOUTHWEST OFFICE • FORT WORTH, TEXAS
SALEM ENGINEERING CO. (Canada) Ltd., TORONTO
SALEM ENGINEERING CO. • SHEFFIELD, ENGLAND

SALEM

ALL OFFICES STAFFED FOR . ENGINEERING, CONSTRUCTION and OPERATION

Salem Builds

CIRCULAR SOAKING PITS
ROTARY HEARTH FURNACES
CONTINUOUS BUTT-WELD FURNACES
CAR BOTTOM FURNACES
FORGE FURNACES
HEAT TREATING FURNACES
HEEDLE METALLIC RECUPERATORS
AIR RECIRCULATING FURNACES
GAS ATMOSPHERE FURNACES
MECHANICAL EQUIPMENT FOR CHARGING AND DISCHARGING MATERIAL FROM FURNACES

Smooth Accurate Regulation

over the entire range of operation with the HAGAN V-Port Butterfly Valve

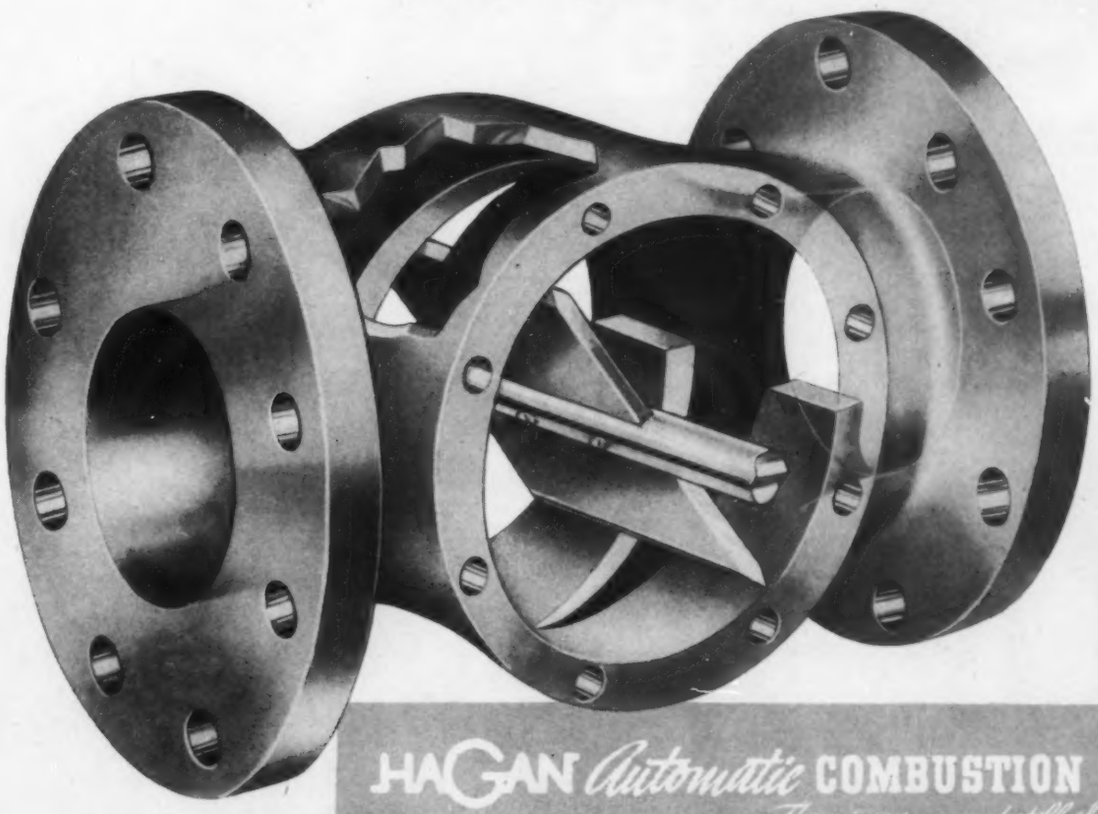
Accurate proportioning of fuel and air is essential in the modern furnace, where heat input may vary over a turndown range of 10 to 1. The need is particularly great at the low rates because at this time steel is up to temperature and most sensitive to furnace atmosphere.

At a minimum flow, the differential across regulating valves is usually the greatest. Losses across the measuring orifice, duct work and burner decrease, so that loss across the regulating butterfly must increase by a corresponding amount.

In the Hagan V-Port Butterfly Valve all of these factors are taken into account in port design, and smooth, accurate regulation is secured over the entire range of operation. The shape of the ports can be made to suit any given set of conditions, so that full advantage is taken of the inherent sensitivity and accuracy of regulating equipment.

Hagan V-Port Butterfly Valves are made in standard pipe sizes. They are ruggedly built and accurately machined. Our engineers will be glad to give you full information.

HAGAN CORPORATION, HAGAN BUILDING · PITTSBURGH 30, PENNSYLVANIA



HAGAN
HALL
BUROMIN
CALGON

HAGAN *Automatic* COMBUSTION CONTROL

The pioneer . . . and still the leader

DOWELL

SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Full blast!

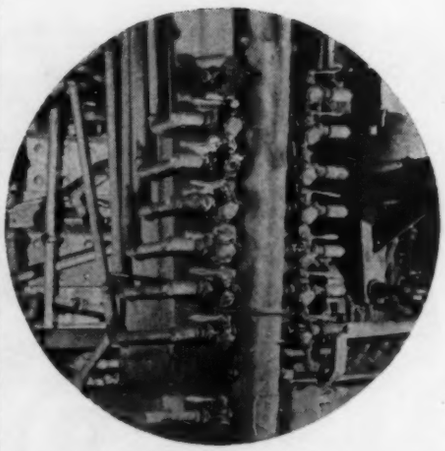
while chemicals clean

the cooling system

The Dowell method of chemically removing scale and sludge from heat exchange equipment has been accepted by many steel plant operators as a rapid, safe and economical way to keep their equipment operating efficiently. In cleaning blast furnace cooling systems by this process, it is not necessary to shut down.

Liquid solvents, carefully selected by Dowell engineers, are pumped into the equipment to be cleaned, filling it to capacity. After a predetermined time, the used solutions are flushed from the unit. Dowell furnishes the necessary trained personnel, truck-mounted tanks, pumps, heaters, mixers and control equipment.

Call the nearest Dowell office for estimates for cleaning: Blast furnaces, open hearth furnaces and other type furnace cooling systems; steam generating equipment—boilers, condensers, economizers, feed water systems; rolling mills cooling systems; engine, compressor and blower jackets; locomotive boilers; water wells, water lines and piping; coke plant equipment—scrubbers, coolers, precipitators, gas lines; building heating, air conditioning, steam and water distribution systems.



DOWELL INCORPORATED, TULSA 3, OKLAHOMA

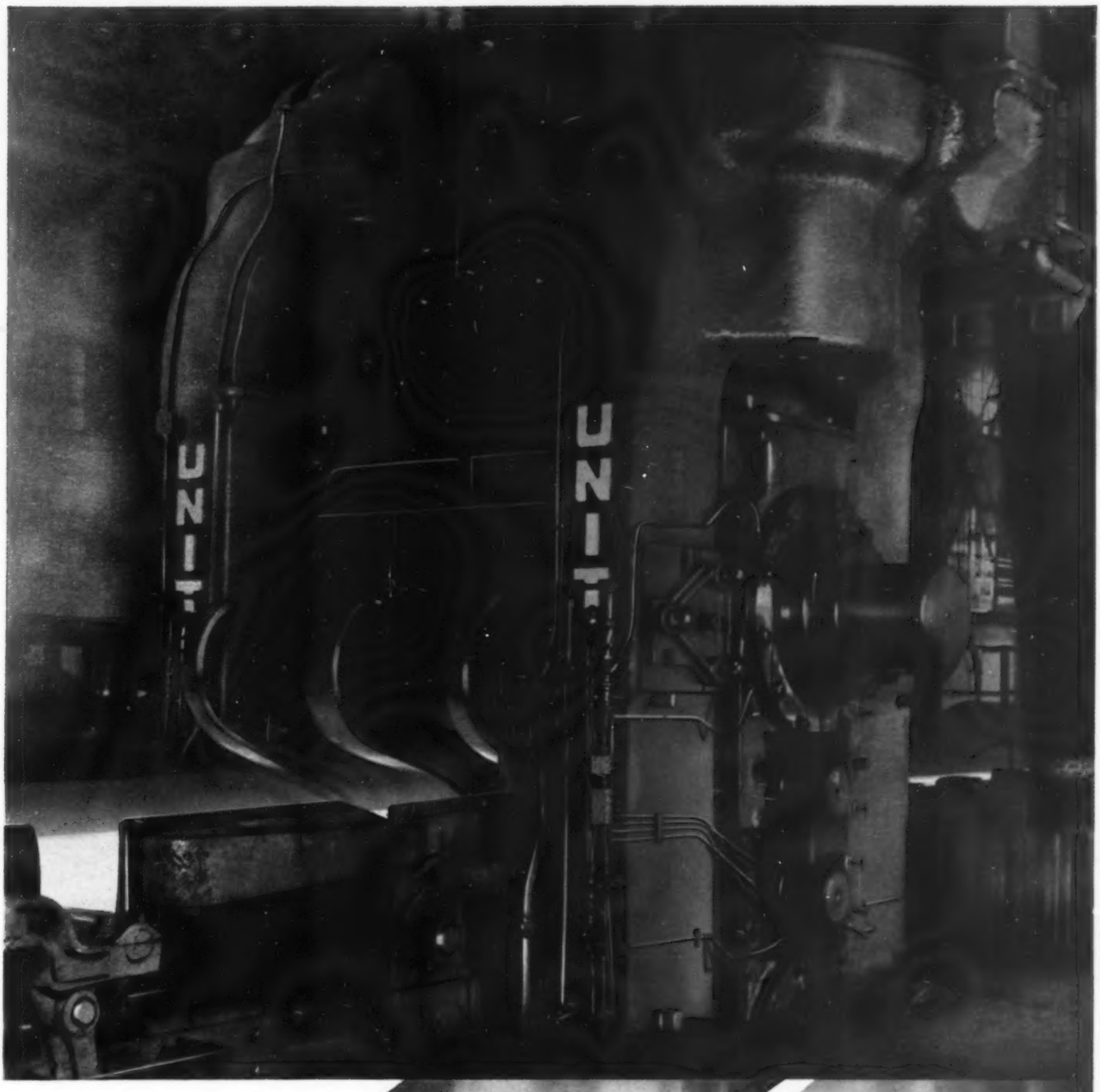
Subsidiary of The Dow Chemical Company

New York, Boston, Philadelphia, Wilmington, Baltimore, Pittsburgh, Buffalo, Cleveland, Cincinnati, Detroit, Chicago, St. Louis, Kansas City, Wichita, Oklahoma City, Houston, Fort Worth, Shreveport, Mt. Pleasant, Michigan; Salem, Ill.; Borger, Texas; Wichita Falls, Texas; Midland, Texas; Lafayette, La.; Hattiesburg, Miss. Long Beach, Casper: Dowell Associate—International Cementers, Inc.

Dowell service is supervised by welded engineers using carefully selected liquid solvents and special mobile equipment.

DOWELL

FOR INDUSTRIAL CHEMICAL SERVICE



UNITED....

FINISHING STAND, 4-HIGH

HOT STRIP MILL

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

PLANTS AT PITTSBURGH·VANDERGRIFT·NEW CASTLE
YOUNGSTOWN·CANTON

Subsidiary: Adamson United Company, Akron, Ohio

Affiliates:
Davy and United Engineering Company, Ltd., Sheffield, England
Dominion Engineering Works, Ltd., Montreal, P. Q. Canada

Even if you now use Industrial Trucks you may still cut handling costs!

Here's how one BAKER TRUCK *customer did it:*

In many plants Material Handling—like Topsy—just grew. Equipment for mechanizing individual handling operations was acquired piece-by-piece as needed. Although time and cost advantages were gained in each case, a lack of integration between departments usually prevented full realization of all the benefits possible.

Take the case of the Hammermill Paper Company in Erie, Pa. Their problem involved handling in process, storing, routing and loading an annual production well over 100,000,000 lbs. of some 3,000 kinds, sizes and colors of paper. Each department had its own electric trucks—and controlled its own handling operations.

Baker Fork Truck tiering pallet loads of bagged starch in storage. Note method of "locking" sacks to prevent side-slipping.

Two years ago, after extensive study by its engineers, the company incorporated all trucks and handling personnel under one department, headed by a qualified expert who administered details and expedited the material handling program. Immediate benefits were:

1. Full utilization of trucks and personnel.
2. More material handled with same equipment.
3. Better maintenance of equipment.
4. Improved transportation service in operating departments.
5. Reduction in material handling costs.

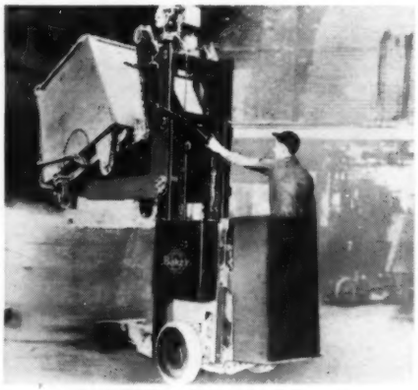
A survey, after the new program had functioned for six months, showed that centralized, as against departmental control, resulted in the utilization of existing trucks to the best advantage in receiving, production, warehousing and shipping departments—providing maximum service at minimum cost.

The program had also resulted in the adoption of the pallet-fork truck method for handling raw, in-process and finished product. Materials such as clay, starch and talc are received in bags. Substantial savings were made by palletizing these bags on arrival and transporting unit loads by fork truck to storage and to production. Still further savings will come when all suppliers can be persuaded to ship material on pallets—negotiations for which are under way. It now takes about 14 hours to palletize a car of 1600 bags—weighing about 50 lbs.—but when material arrives already palletized unloading and warehousing can be completed in about 2 hours per car.

Baker Fork Truck picking up unit load of lap pulp for loading into box-car for shipment.

Palletizing also resulted in cutting unloading time of knocked-down shipping cartons for 24 hours per car, when they arrived loose, to approximately 3 hours, since they arrive in unit loads strapped to pallets, permitting fork-truck handling.

Additional benefits from centralized control of handling were reported when another survey was made at the end of 1946. Departmental superintendents, freed of material handling problems could now concentrate on production. Plant safety had been improved. Extension of mechanized handling eliminated much heavy manual labor—making these men available for higher paid, productive work.



Substantial savings were made by using a Baker Hy-Lift Truck with special tilt-type platform for charging beaters with pulp.

Work flow has been made more efficient and direct. With all handling under one control, proper allotment assures adequate equipment for all departments. Maintenance costs on trucks were lowered. The pallet-fork truck method, besides saving as mentioned, effectively solved the problem of handling a wide diversity of products and sizes of packages—incoming materials and outgoing products.

A new warehouse, just completed, was designed around mechanized handling of unit loads. Tractor-trailer trains are assisted by fork trucks—permitting efficient, orderly storage, full utilization of space by tiering, and speeding order assembly for shipment.

Centralization of handling operations can be applied in large or small plants. If you want maximum benefits from your modern handling equipment, a Baker Material Handling Engineer can help you set up a central control in your plant.

BAKER INDUSTRIAL TRUCK DIVISION *of The Baker-Raulang Company*

2166 West 25th Street • Cleveland, Ohio

In Canada: Railway & Power Engineering Corporation, Limited

See us at Booth 303
Materials Handling Exposition
Cleveland January 12-16

2200-1-47

Baker INDUSTRIAL TRUCKS

DUAL CONTROL for CRANES by E&M

EC&M builds a complete line of control, brakes, and limit stops engineered to the needs of each application. Cab-controlled cranes usually have fast bridge speeds for high production, with floor-controlled bridge speeds limited to accommodate the man walking with the load. In this new combination floor and cab type, the bridge running speed is maximum when the crane is operated from the cab, and is automatically reduced when controlled from the push button station at floor level. Put your crane control requirements up to EC&M for efficient operation at low up-keep expense.

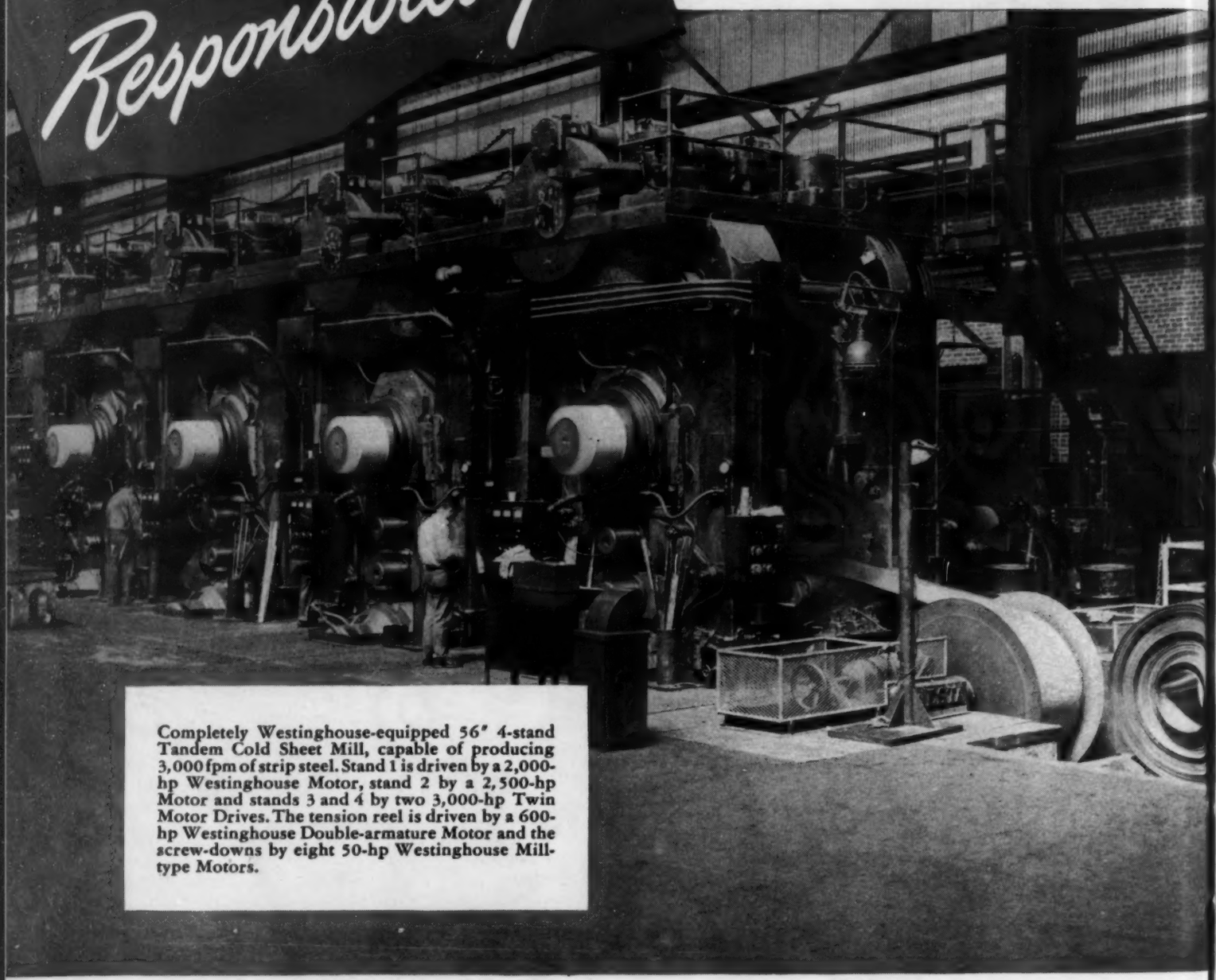
This new *combination* system of control saves time, delays, or demurrage whenever the operator has climbed down from the cab and occasional lifts become necessary. The crane can then be operated at floor level, from the pendant push button station, to handle incoming or outgoing shipments arriving during *noon-hours*, after the *end of a working day*, or during the *night shift*.

This control is especially well suited to cranes in warehouse service. It is equally advantageous for certain foundry or machine-shop operations where floor-control eliminates the necessity of climbing up into the cab to handle the occasional piece. This EC&M dual crane control, permitting operation from either cab or floor, is available for both alternating and direct current cranes of all capacities and makes. Our nearby office will be glad to discuss your requirements and furnish complete details.

THE ELECTRIC CONTROLLER AND MANUFACTURING CO.

2698 East 79th Street Cleveland 4, Ohio

KEY TO MORE *Unit Responsibility*



Completely Westinghouse-equipped 56" 4-stand Tandem Cold Sheet Mill, capable of producing 3,000 fpm of strip steel. Stand 1 is driven by a 2,000-hp Westinghouse Motor, stand 2 by a 2,500-hp Motor and stands 3 and 4 by two 3,000-hp Twin Motor Drives. The tension reel is driven by a 600-hp Westinghouse Double-armature Motor and the screw-downs by eight 50-hp Westinghouse Mill-type Motors.

FROM PLANNING BOARD TO PRODUCTION . . . YOUR BEST ANSWER TO ALL OF YOUR ELECTRICAL AND POWER PROBLEMS

The high production rate of today's steel mills is a story of continuous development in methods and machines. The trend is toward a higher degree of electrification very necessary for flexible power and accurate control.

In this development program, Westinghouse has been responsible for an impressive list of important contributions to the steel industry, worked out in co-operation with steel mill engineers.

For this reason, Westinghouse today is regarded as an operating partner of the steel industry, offering engineering "know-how" and a single source for apparatus—for every electrical or power problem. The result is the highest degree of co-ordinated electrification.

For help in working out your problems—for the best in drive, control and lighting equipment—call on Westinghouse. It's your soundest assurance of maximum performance and dependability. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-94769

PRODUCTIVE POWER

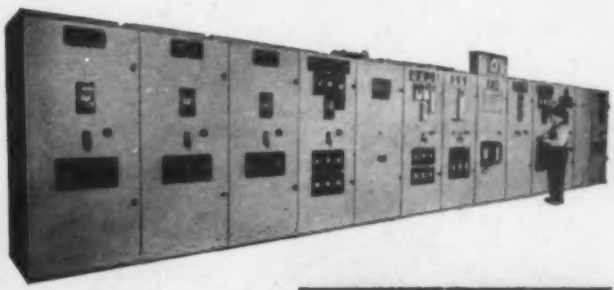
"WESTINGHOUSE-EQUIPPED THROUGHOUT" MEANS SIMPLIFIED ORDERING, QUICKER INSTALLATION, MORE EFFICIENT OPERATION

Putting power to work *productively* can be a major problem . . . or a simple one. When items must be selected, ordered and received from many sources, it means many chances for costly errors and delays . . . divided responsibility for performance of installed equipment.

Westinghouse offers the way to simplify the job. From equipment for generation of electrical or steam power, to the most specialized types of drives, gearing and control for its utilization, Westinghouse provides a single source of supply . . . competent to take responsibility for performance of all parts of the job.

A typical example of Westinghouse unit responsibility is the installation of a 56" Tandem Cold Mill—illustrated on these pages. This is one of today's most modern mills. It is completely Westinghouse-equipped, and is Rototrol-regulated for fully automatic control of speed and tension.

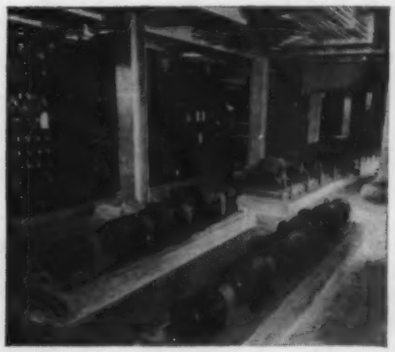
COIL CONVEYOR system between hot mills and tandem cold mill. The tapered rolls comprising the 90° bend are synchronized with the conveyors by use of variable frequency drives. Eleven 35-hp Westinghouse Mill Motors drive about 1,000 feet of conveyor. Five 1-hp Westinghouse Gearmotors drive the 90° bend.



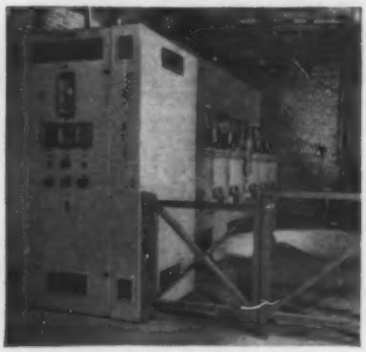
SWITCHGEAR — 6,600-volt Westinghouse Metal-clad Switchgear for entire cold mill. Includes high-voltage, a-c circuits for tandem mill, skin-pass mill and 7 Power Centers.

AIR CLEANING—108,000 cfm Westinghouse Precipitron, for cleaning the air from the 8,000-kw synchronous m-g set, prior to recirculating the air into the motor room.

MOTOR ROOM of tandem sheet mill. On the left are Westinghouse Main Roll Drive Motors. In the background is an 8,000-kw Westinghouse M-G Set. Exciters, Rototrols and I-R Drop Compensator are in the right foreground.



CONTROL panels, exciters and Rototrols for two single-stand, skin-pass mills. Here complex control problem is simplified by systematic location of many conduits.



RECTIFICATION — This 1,000-kw Westinghouse Ignitron Rectifier provides d-c power for auxiliaries requiring constant voltage.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

MORE PRODUCTIVE POWER FOR INDUSTRY

back of the steel castings that "Keep 'em Rolling"

Getting the most service out of transportation equipment calls for tough, wear-resistant alloy steel castings on rolling stock, track crossings, switches, and in yards and shops. Makers of the electric furnace steels for these castings depend on International Graphite Electrodes as an essential factor to electric steel quality. They have proved to their own satisfaction in the severest tests of all – in actual furnace operation under a wide range of requirements – that International Graphite Electrodes offer physical, electrical and chemical properties in the right combination.

Specify International Electrodes for economical performance and all around satisfaction; you'll see why furnace operators everywhere prefer them. Write for complete information today.

INTERNATIONAL GRAPHITE ELECTRODES

Specify INTERNATIONAL Graphite Electrodes for – Slow consumption – High current capacity – Low rate of oxidation–High thermal conductivity–High degree of purity–Consistently uniform properties and dimensions – Low cost per ton of production.

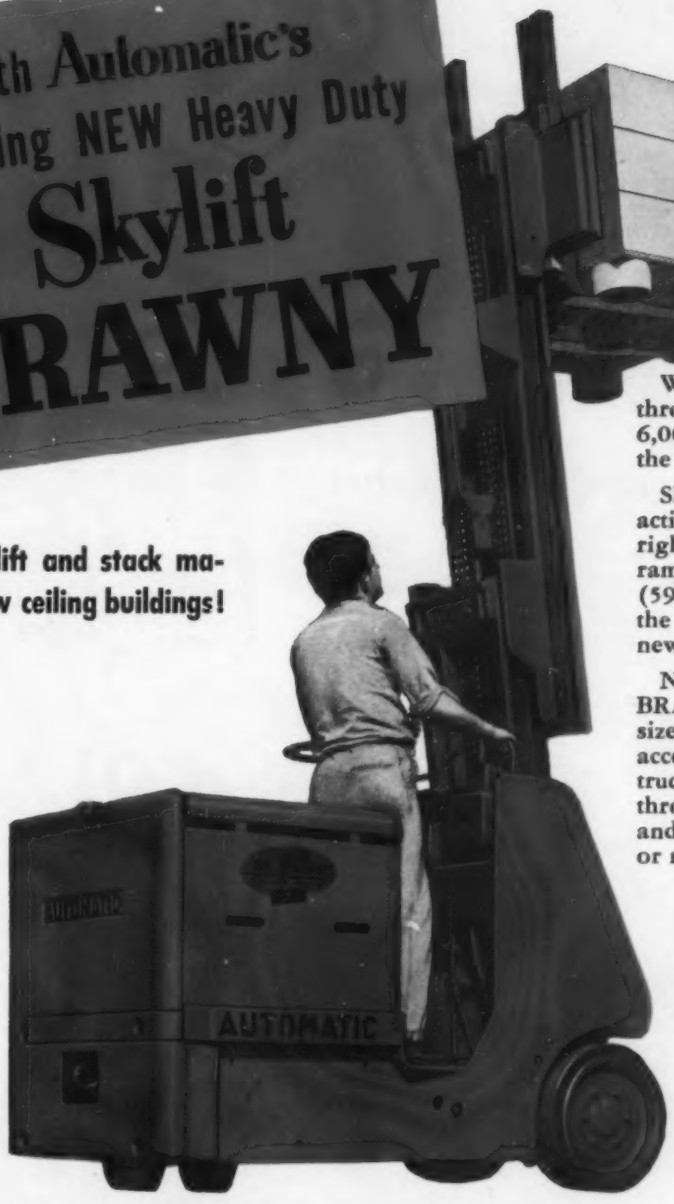
ICE

International Graphite & Electrode Corp.

SAINT MARYS, PA.

NOW! STACK HEAVIEST LOADS TO 124 INCHES
2-4 TON LOADS TO NEW HEIGHTS

With Automatic's Amazing NEW Heavy Duty **Skylift BRAWNY**



Tiers 5 inches higher than any other fork truck of like capacity

Now, for the first time, amazing new Skylift BRAWNY lifts loads of 4,000 to 8,000 pounds to *heights never before attained* in heavy-duty fork trucks of like capacity. Yet, it also tiers to ceiling heights in boxcars and low-clearance buildings, is smaller, lighter, compact!

With a collapsed height of 83 inches (pass through standard 7 foot door), the 4, 5 and 6,000 pound BRAWNYS lift to 124 inches—the 7 and 8,000 pound models to 115 inches.

Skylift BRAWNY'S hydraulic lift telescopic action, is engineered so that the forks and uprights are raised independently by separate rams. The forks thus raise to 62½ inches (59½ for 7 and 8,000 pound models) before the uprights begin to extend. So you stack to new heights, yet tier in low ceiling buildings.

Yet move, lift and stack material in low ceiling buildings!

NEWmatic Controller makes the Skylift BRAWNY easier to handle than any similar sized truck. It eliminates tire slippage. When acceleration is applied, the NEWmatic starts truck in first speed and automatically passes through faster speeds. Thus you get extra safety and economy—truck can be started in forward or reverse only when in low speed or neutral.

Let an ATCO Specialist show you how much this amazing new Skylift BRAWNY can *cut your material handling costs*—give you *floor-to-ceiling, extra free storage space.* Mail the coupon today!

Be Sure to Attend Jan. 12-16

2ND NATIONAL MATERIALS HANDLING EXPOSITION
CLEVELAND AUDITORIUM
JANUARY 12-16 1948

LOOK TO THE LEADER FOR ALL THAT'S NEW!

Skylift BRAWNY
A PRODUCT OF AUTOMATIC
Lightens LIFE'S LOADS

MANUFACTURERS OF THE FAMOUS TRANSPORTERS, TRANSTACKERS AND SKYLIFT ELECTRIC TRUCKS

AUTOMATIC TRANSPORTATION COMPANY
DIV. OF THE YALE & TOWNE MFG. CO.
155 West 87th Street, Dept. X-7, Chicago 20, Ill.

Please mail me, without cost, complete facts on your new Skylift BRAWNY Electric Truck.

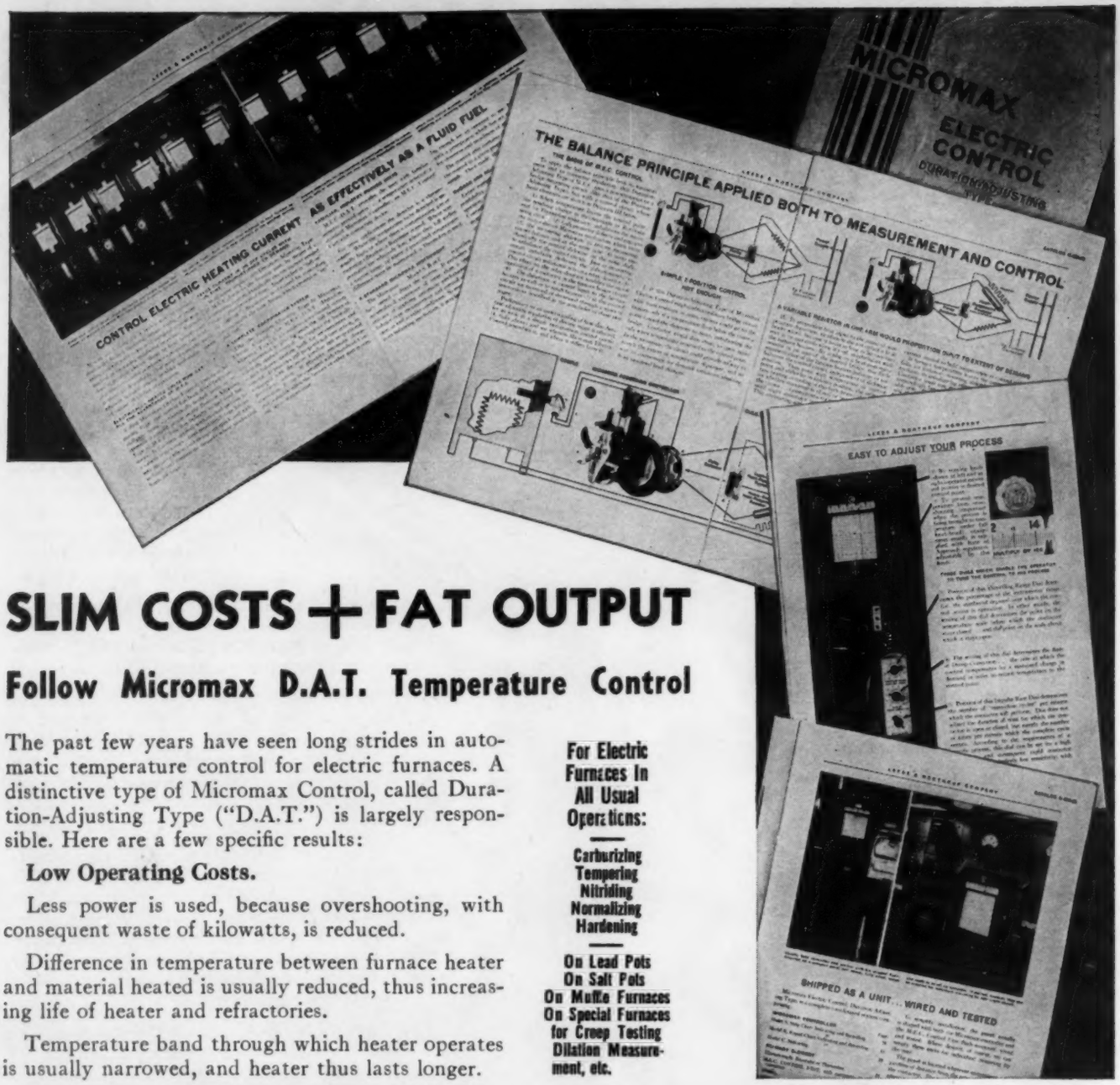
☐ Have an ATCO Specialist make a free survey of my material handling costs.

Company Name.....

By.....*Position*.....

Street Address.....

City.....*Zone*.....*State*.....


CONTROL ELECTRIC HEATING CURRENT AS EFFECTIVELY AS A FLUID FUEL
THE BALANCE PRINCIPLE APPLIED BOTH TO MEASUREMENT AND CONTROL
MICROMAX
ELECTRIC
CONTROL
EASY TO ADJUST YOUR PROCESS
SHIPPED AS A UNIT . . . WIRED AND TESTED

SLIM COSTS + FAT OUTPUT

Follow Micromax D.A.T. Temperature Control

The past few years have seen long strides in automatic temperature control for electric furnaces. A distinctive type of Micromax Control, called Duration-Adjusting Type ("D.A.T.") is largely responsible. Here are a few specific results:

Low Operating Costs.

Less power is used, because overshooting, with consequent waste of kilowatts, is reduced.

Difference in temperature between furnace heater and material heated is usually reduced, thus increasing life of heater and refractories.

Temperature band through which heater operates is usually narrowed, and heater thus lasts longer.

Heat Balance is Precise, and Control is Stable.

Every change in the furnace's need for heat is automatically balanced by a change in the amount supplied. Balance is accurately proportioned at all times, in spite of changes in load, ambient temperature, etc. This stability is what makes accuracy useful — it holds temperature so constant that you can take full advantage of temperature control, to protect quality of product.

Catalog N-00A(2), partly shown above, will be sent on request. Leeds & Northrup Company, 4942 Stenton Avenue, Philadelphia 44, Pa.

For Electric Furnaces In All Usual Operations:

Carburizing
Tempering
Nitriding
Normalizing
Hardening

On Lead Pots
On Salt Pots
On Muffle Furnaces
On Special Furnaces for Creep Testing
Dilation Measurement, etc.

Duration-Adjusting Type of Micromax Electric Control gives (1) Fully-proportioned time action as distinguished from the more familiar fully-proportioned positioning action; (2) Automatic droop correction; (3) Overshoot control.

MEC-DAT gives the same close, steady control of electric furnaces that a valve-positioning MEC gives to fuel fired furnaces. But it doesn't throttle the electric power in order to balance its input against the heat demand. Instead, using an on-off contacting system, the Controller regulates the durations of time during which power is on and off. Hence its name, Duration-Adjusting Type MEC.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad N-00A(5c)

Pennsylvania presents a new DISTRIBUTION TRANSFORMER

embodying a new wound core design with an inherent low exciting current

MODERN IN DESIGN. - ECONOMICAL IN OPERATION. RELIABLE IN SERVICE.

Here at last is a post-war, improved Distribution Transformer that embraces the fundamentals of good design, good engineering and good workmanship.

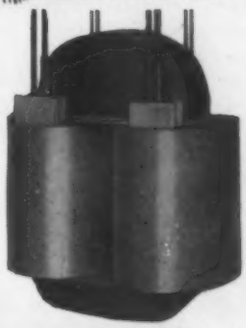
Outstanding among the features of this transformer is the remarkable new core that Pennsylvania has developed. The small, compact core is wound of the finest grade, high permeability, cold-rolled, oriented, Silicon steel. Each lamination makes a complete turn with a single lap to form a flux path of its own. The extra steel at the lap joint keeps losses and exciting current down to a very low point.

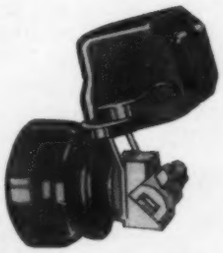
Core laminations are so arranged, they may be removed from the coils and reassembled without special tools and without changing the electrical characteristics of the steel. Pennsylvania's core design enables restacking of the core without fear of encountering high core loss or high exciting current.

A New DISTRIBUTION TRANSFORMER
EMBODYING A NEW WOUND CORE DESIGN WITH AN INHERENT LOW EXCITING CURRENT
25 Kva and below—14400 volts and below. Single Phase, 60 Cycles, OISC.

LAMINATIONS INDIVIDUALLY LAPPED

Where the two ends of individual laminations come together they are overlapped. This 100% additional cross-section area at the lap reduces the density and prevents a concentration of flux.





HINGED INSULATING CAPS

Live parts of high voltage bushings are protected by insulating caps hinged to the hardware. Self-guiding caps swing in and out of position on non-corrosive spring hinges.

METAL ENCLOSED BUSHING GASKETS

Exposed edges of bushing gaskets are protected from the weather by copper rims. Bushing openings into the tank are embossed inward to provide flat surfaces for the gaskets and to reduce the projected floor space.

NO BUTT JOINTS... NO GAPS...

Because laminations are individually lapped, no gaps are present in the core. This construction assures a low exciting current.

For more details about Pennsylvania's NEW Distribution Transformer, write for 8-page Booklet No. 1147.

Fill out and mail this handy coupon today

Pennsylvania

TRANSFORMER COMPANY

Box 6208 - Pittsburgh 12, Pa.

TO—Pennsylvania Transformer Company
Box 6208, Pittsburgh 12, Pennsylvania

Please send me free Distribution Transformer Booklet No. 1147.

Name_____

Firm Name_____ Title_____

Address_____

City_____ Zone____ State_____

fast, new ingot-buggy drive ...eliminates heavy contactors ...uses fewer collector rails ...costs less to maintain

engineered drive assures fast delivery of ingot to mill despite increased buggy travel and higher rolling speeds

As an important factor in boosting production, General Electric's new ingot-buggy drive has caught the interest of many mill operators. The past decade saw ingot size, buggy travel distance, and rolling speeds increase to a point where the conventional buggy drive had become highly inadequate. Power losses during acceleration and deceleration were excessive. Braking difficulties were experienced and the cost of maintaining a large number of control contactors and collector rails was high.

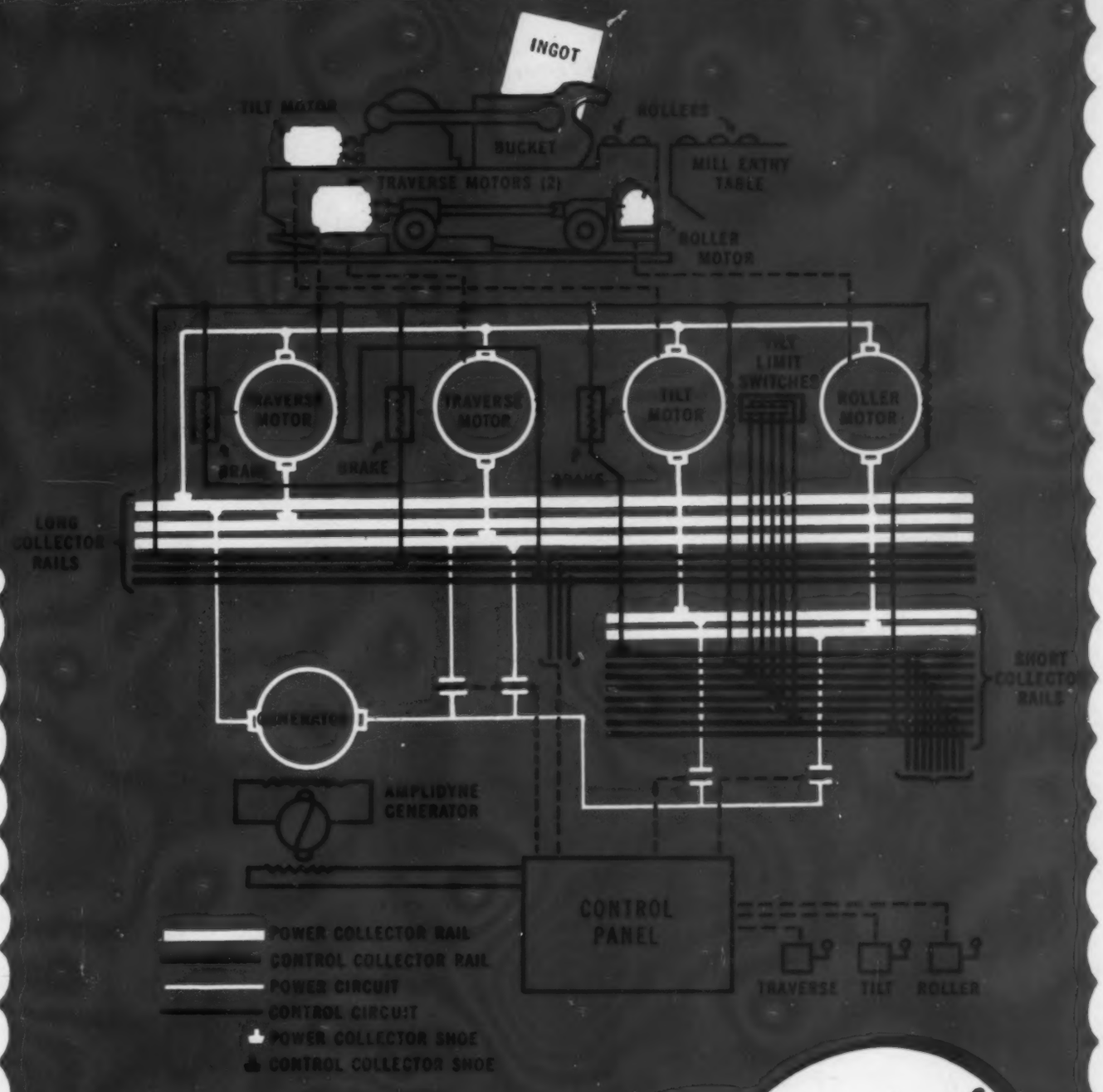
Initial use of the new General Electric ingot-buggy drive proved it has overcome these disadvantages. Built around an adjustable-voltage amplidyne control system, the new drive gives the operator these advantages:

- ***Motor torque is applied smoothly and uniformly thereby permitting higher rates of acceleration and deceleration.***
- ***Operating speeds are higher because of the ability of mill-type motors to operate on double armature voltage.***
- ***The number of collector rails and control devices is reduced.***
- ***Mechanical wear and tear is reduced; brakes are used only for holding and emergency stopping.***
- ***Assures minimum mechanical and electrical maintenance.***

This new drive is a good example of the ability of General Electric to meet industry's demand for higher speed and more accurate control in electric drives. Moreover, when the operator brings his drive problems to General Electric, he avoids considerable trouble and expense because the task of co-ordinating the components of a modern electric drive is assumed by a General Electric application engineer. From preliminary engineering to final checkup after installation, the operator can draw on the experience and counsel of a trained specialist. Whether you are considering the installation of a new drive or the modernization of an old drive, it will pay you to talk to the General Electric steel mill engineer in your locality. No obligation, of course. *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*

Shown here are typical soaking pits in a rolling mill with an ingot crane transferring an ingot to the buggy at the far left.

GENERAL ELECTRIC



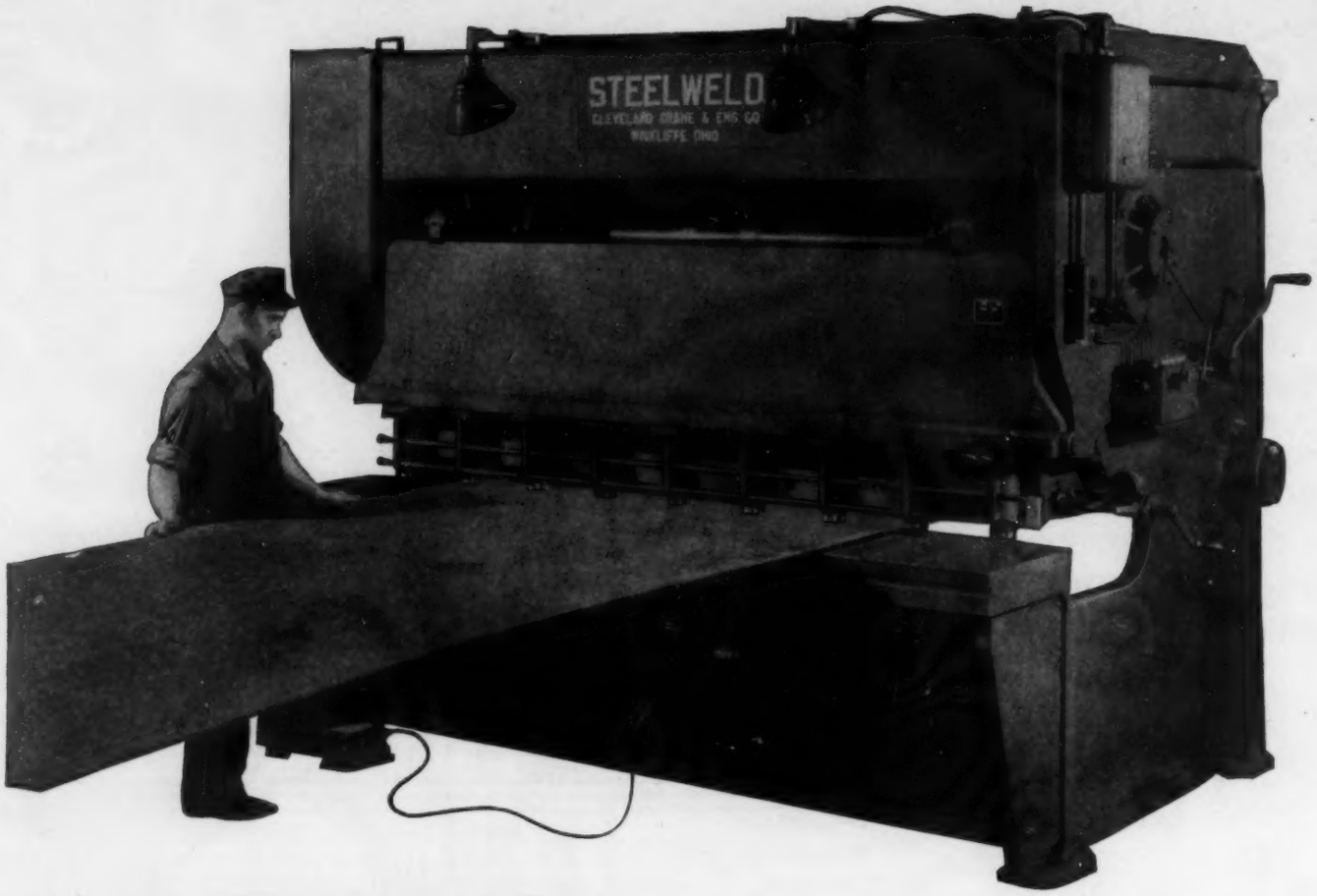
PLAN OF A TYPICAL G-E INGOT-BUGGY DRIVE

All control and power circuits are connected to the buggy by collector rails with collector shoes. Control signals are fed into a General Electric amplidyne. The latter functions as a regulating exciter. It amplifies the control signal and uses it to vary the excitation of the main generator which supplies power to the two traverse motors, the tilt motor, or the roller motor, as selected by the operator. The motors slow down or speed up as armature voltage is varied by decreasing or increasing excitation of the main generator. During regenerative braking, full braking torque can be developed at the lowest speeds by this same control.

another example of

GE

drive engineering at work!



ALL STEELWELD SHEARS
CONTROLLED ELECTRICALLY...

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STEELWELD PIVOTED BLADE SHEARS

Crops *and* Shorts

WHILE Democrats and Republicans are busy trying to affix on each other the blame for intlation, everyone seems to ignore the basic reason of higher wages without a corresponding increase in productivity. A dollar won't do as much as it used to because we don't do as much for the dollar as we used to.

A survey of the building trades shows that productivity is actually down about 40 per cent under prewar figures, while hourly wage rates are up 75 per cent. Combine these two factors and we find costs 190 per cent higher. There is an irrefutable axiom that we cannot buy more than we produce — it's a pity that everyone can't believe it.

▲

IN spite of the fact that steel prices have increased only about 45 per cent, as compared to increases of 90–180 per cent in food, farm products, building materials and other items, steel seems to be the whipping boy for price and wage controls. Government officials, who, when John L. Lewis was in their hair, treated the miners so liberally, now fear another steel wage increase and a consequent price increase. That their fears are well grounded is indicated by the action of CIO officials, who are definitely planning another round of wage increases when the time for negotiation comes up.

▲

DIGNITY has been defined as the ability to hold back on the tongue what never should have been on the mind in the first place.

▲

STILL another case of steel consumers' entry into the steel business is the purchase of Empire Steel Corporation, Mansfield, Ohio, by Studebaker Corporation. The sale price was $7,430,000. Empire has six open hearth furnaces with an ingot capacity of 348,540 tons per year, as well as a 32 in. blooming mill, a 24 in. sheet bar mill, and sheet mills. Capacity is available for 120,000 tons per year of hot rolled sheets. The automobile company will not take all of Empire's production, but estimate that they will be able to increase its automotive production by 25 per cent.

▲

FOLLOWING the same general trend, steel companies are reaching back in their supply lines by acquiring coal properties. Interlake Iron Company, Pickands, Mather and Company, Youngstown Sheet and Tube Company and Steel Company of Canada banded together to buy Carter Coal Company. The coal company, holding considerable reserves in the Pocahontas field around Welch, West Virginia, has been out of production since mid-year because of labor trouble.

▲

THE most trying ten years of a woman's life are between the ages of 25 and 30.

▲

ON PAGE 117 of this issue will be found a new type of index for the Iron and Steel Engineer. It is an index of the products advertised in this particular issue, as well as those listed in the news supplement columns. This is an added service to readers of the Iron and Steel Engineer, as the postcard on that page provides a simple, convenient way for the reader to obtain additional information about any of these products. We believe our readers will find it useful. We hope they will make use of it.

▲

THE hourly production rate of the steel industry of the United States is now almost equal to the annual rate during the Civil War.

▲

FOR every four tons of finished wrought steel required by American industry, there is one ton of castings needed, according to R. L. Collier, vice-president of the Gray Iron Founders' Society. Mr. Collier believes that recognition of this fact by the steel industry will lead to more adequate pig iron supplies for foundries.

▲

DON'T spend the money you expect to get through income tax reductions next year. Indications are that, because of increased commitments for foreign aid, tax reductions will be considerably less than those in the bills vetoed this year.

▲

REPRESENTATIVE Joseph E. Martin of Massachusetts brought forth a good idea when he said: "We will take the government out of the people's hair and put it back into their hands."

▲

CURRENT newspaper headlines, featuring riots, civil wars and general strikes in various foreign countries, are scarcely conducive to the Christmas spirit. But here in the United States, sheltered by booming business and plentiful money, we will no doubt have the usual merry holidays, with all the gadgets and furbelows that go with the season (neckties are unusually lurid this year). We hope that the more serious side of the season will not be overlooked — a little more religion might go far in curing many of the ills that afflict the world.

The Iron and Steel Engineer staff extends to each and every one of its friends sincere best wishes for a joyous Christmas and a happy, prosperous New Year.

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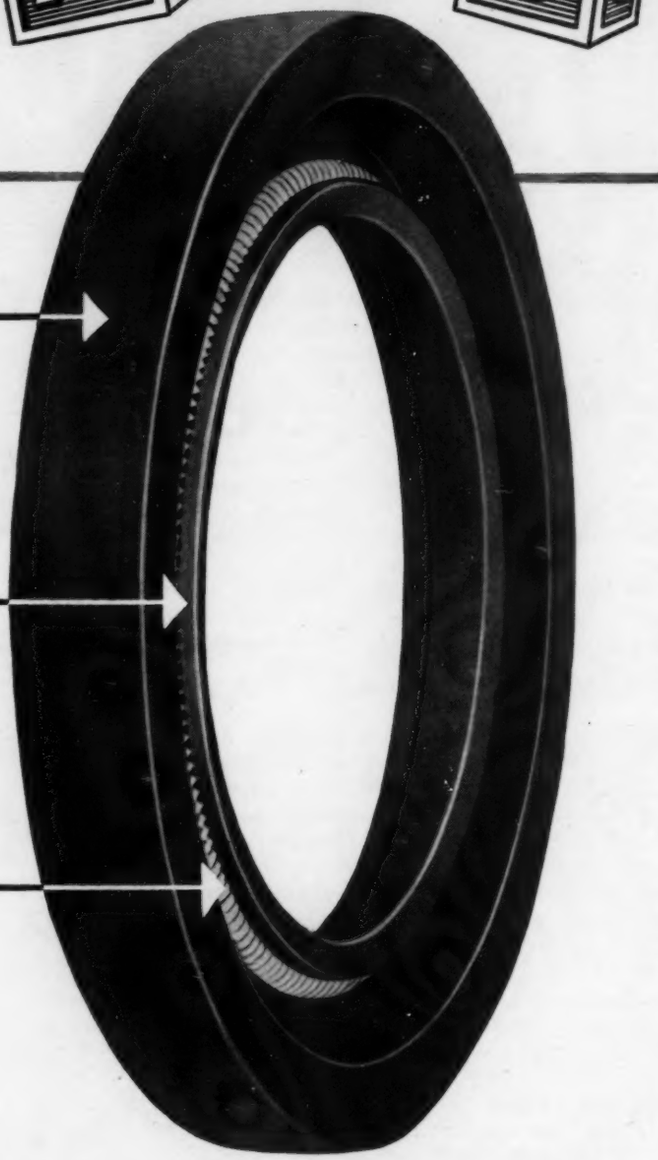

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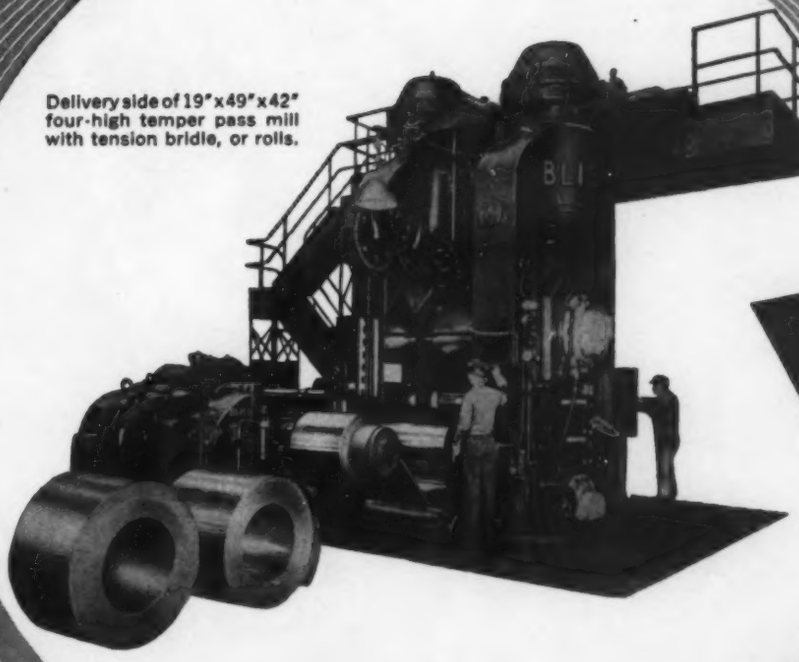

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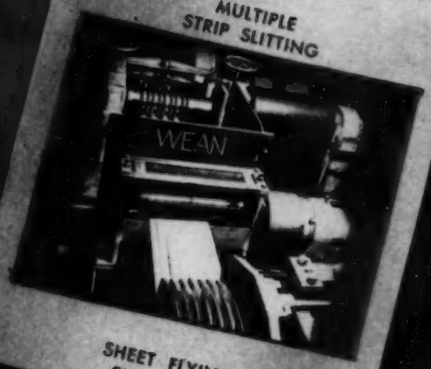
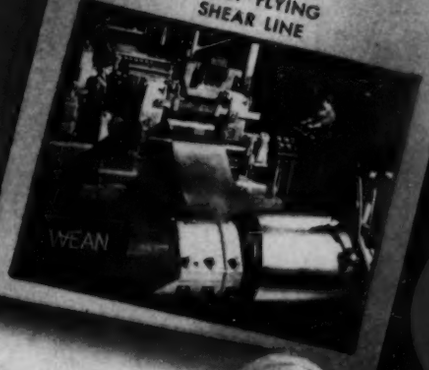

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Iron and Steel ENGINEER

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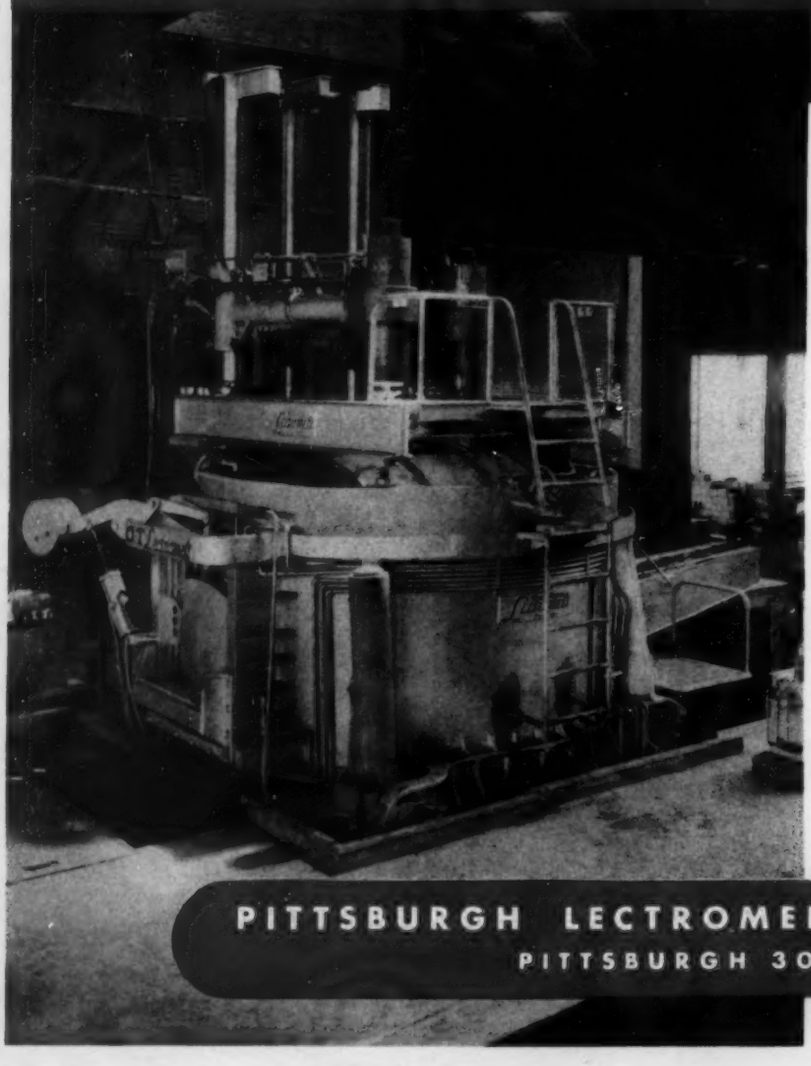

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Metal Spray Practice
IN STEEL PLANTS

. . . . metal spraying offers many possibilities in the repair of worn parts . . . . however, proper procedure and particularly proper preparation is required . . . .

By A. E. CICHELLI
Lubrication Engineer
Bethlehem Steel Company
Sparrows Point, Maryland

▲ FROM the inception of the industrial era, the problem of what to do with worn out parts has always been with us. Many and devious ways have been successfully, and sometimes not too successfully, employed to meet this problem. In view of the peculiar individuality each specific problem possesses, it becomes evident that no one solution can possibly satisfy them all. Corrective measures are nearly always temporary expedients, such as part replacement, remachining to a smaller size, or rebuilding by metal deposition. Good design and good lubrication, of course, are the real solutions; but though these are ends to be sought, they are not always achieved. For that reason, industry must resort to the more or less provisional means mentioned.

This paper concerns itself only with metal deposition and a specific kind at that, known as either metal spraying or metallizing. Here we plan to show how this method of metal build-up has fitted into steel plant maintenance. In particular, we intend to discuss the experiences we have had in Bethlehem Steel Company's plant at Sparrows Point.

Being a method of metal deposition, metal spraying has to compete with and supplement welding, brazing, electroplating and other well known processes. In some problems we find that it is the ideal answer; in others there is a question as to its economy; and still in others, the method just cannot be applied.

The process is a development stemming from Dr. Schoop's discovery, in Switzerland in 1909, that metallic powders can be projected in a stream and made to imbed themselves on a roughened surface. The first machines consisted of an air blast directed onto a molten stream of metal. Since this unit was not portable, it was quickly outmoded by Dr. Schoop's powder gun. This had the advantage of portability and was relatively simple in design. Metallic powders were drawn by suction up into the nozzle and then passed through a flame which heated the metal into a plastic state as it was being projected in a stream of minute particles. The powder process is in use even today. In fact, recent developments are showing an expanding usage as in the field of plastic spraying.

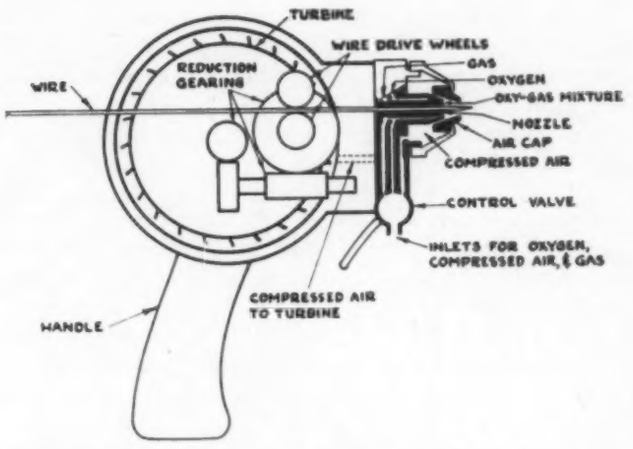


Figure 1 — Diagram of typical wire type metal spray gun.

However, powder spraying, as it was first developed, had its limitations; and so inventors began work on a wire spray gun. Continuing his own work, Dr. Schoop produced a wire spraying unit shortly after the developed his powder gun. Originally intended for decorative purposes, it was not long before the process was used to coat surfaces for corrosion protection and then to build up after wear.

Fifteen years ago, when a spray gun was first introduced at our plant, there were very few who had faith in its survival. As a matter of fact, it was many years later before enough confidence was evinced in this new tool so that shop orders began asking for metal spray in preference to other methods of repair. Prior to that, it took a great deal of salesmanship and just plain nerve to have a job tried. Unfortunately for the process, many jobs were attempted without the preliminary study necessary for full recognition of its limitations.

As pointed out earlier, metal spraying is a process of projecting a stream of hot plastic metal particles onto

Presented before AISE Philadelphia District Section Meeting, February 1, 1947

Figure 2 — Photomicrographs showing section through low carbon steel sprayed on a cast iron base with an electrically prepared surface. The picture on the right has a magnification five times that on the left.

a surface especially prepared to receive and hold them. There are two principal types; the one using metal powders and the other using wire as the material atomized. Powder guns are not used in the Sparrows Point plant, therefore, our remarks will be confined to the wire spraying type.

Wire, in coils or on spools, whose sizes range from 24 B&S gage up to $\frac{1}{8}$ in. for the average type spray unit is supported on a feed reel stand and fed into the rear of the gun. Figure 1 shows a cut of a typical gun. A pair of feed rolls, a driver and an idler, grip the wire as it proceeds straight through the gun. One feed roll is driven by an air turbine whose speed is appropriately reduced through a small gear reducer incorporated in the casing. Some guns are equipped with governors for speed control while others have needle valves for that purpose.

Upon reaching the exit end of the gun, the wire is fed through the center of a copper nozzle which is equipped with a series of small preheating flame ports surrounding the wire. The flame itself is comprised of oxygen and a combustible gas. Air used for atomization is expelled around the periphery of this nozzle. Since air must be dry and clean for spraying, an air filter is inserted ahead of the gun. A petcock with ports for oxygen, air and fuel gas allows all three gases to be handled together. Hot metallic particles streaming from the end of the nozzle fan out and are made to travel about 6 or 7 inches before striking a prepared surface. Guns can be mounted on a lathe tool-post or can be handled manually as needed. Guns from different vendors have different weights that range from 4 to 10 lb. The 10-lb gun has been developed recently for spraying wire up to $\frac{3}{16}$ in. in diameter and is capable of spraying 20 lb of steel per hour.

Gases used for melting the wire at the nozzle are oxygen-acetylene or oxygen-propane, principally. We have used both combinations and find that when a large job has to be done, oxy-propane is the more economical. Propane's economy results from higher spraying speeds that accompany higher pressures. In using oxygen and propane, our pressures are: air 65 psi, oxygen 27 psi, and propane 25 psi. When using acetylene for fuel, oxygen drops back to 17 psi and acetylene, 15 psi. There are other considerations in regard to fuel gas selection that should be mentioned at this time. Though speed and economy are important, flame cleanliness and degree of atomization must not be overlooked. Tests show that propane deposits more dust and produces poorer atomization.

Spraying technique itself is relatively simple, but some precautions have to be taken, nevertheless. First of all, if the wire has twists or kinks, a straightening device mounted on the feed reel stand is necessary to remove them. Second, a neutral flame is necessary in the gun to insure a minimum of oxides in the coating as well as proper atomization. Pressures must be watched so that a good steady stream can be maintained throughout a job.

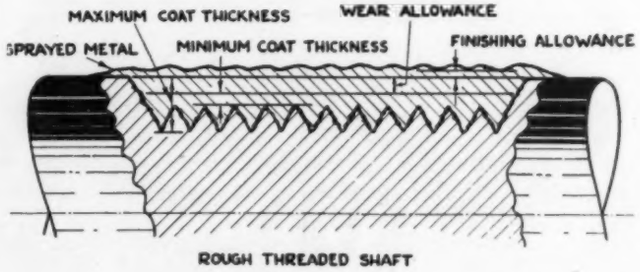
Aside from the gun itself, metallizing is a process of several parts, surface preparation, surface coating, and surface finishing. Above all else, surface preparation is important. Success of an application depends almost entirely on the tightness of the bond, or the interlocking and imbedding of the metallic particles on the surface to be coated. Unless the surface is rough and at the same time devoid of contamination, such as oily films, a weak bond will result. For that reason, our attention will be first focused on preparation. As stated, the prime function of preparation is to thoroughly clean the surface so as to expose virgin, unoxidized, or otherwise uncontaminated metal. The second function is to provide pores, minute cavities or grooves, or any hollow that can be filled with sprayed metal keys. Unless cleanliness and roughness are achieved, metallizing is useless, for a metallized section is no stronger than its linkage with the base metal. In view of the large variety of metals and shapes in use in machine elements that offer desirable metal spray applications, different methods of preparation have been found useful under varying conditions.

Sand or grit blasting is used for preparing large areas, the former where its recovery is impossible. Where sand blasting is used, it is important that the sand be dry and about 16 mesh. An angular or hard silica sand is found to be quite satisfactory. A smoother type of sand cleans the surface, but does not make it quite rough enough. Too coarse a sand results in an excellent surface,

Figure 3 — This table gives the preparation and coating thicknesses for a rough, threaded shaft.

SHAFT DIAMETER	THREADS PER INCH	DEPTH OF THREAD	MINIMUM COAT THICKNESS	MAXIMUM COAT THICKNESS	FINISHING ALLOWANCE
1" TO 4"	16	.054"	.010"-.025"	.150"	.015"-.020"
4" TO 12"	14	.062"	.030"-.040"	.180"	.020"-.030"
12" & UP	12	.072"	.040"	.210"	.030"

MINIMUM COAT THICKNESS MEASURED FROM TOP OF THREAD
MAXIMUM COAT THICKNESS MEASURED FROM BOTTOM OF THREAD
MINIMUM COAT THICKNESS FOR ALL PRESS FITS IS .010"



but a costly one, in that it is a slower process. Equipment for sand blasting is generally portable, one such unit in our plant holding 1½ drums of sand and capable of cleaning 100 sq ft in one hour. It is simply a large drum on wheels with connections for an air hose and an aspirator. Sand, though satisfactory, is only used when a job has to be done in place, and then precautions must be taken to prevent sand from flying all over the surrounding area. Needless to say, a few dollars saved on one metal spray job may be thrown away many times by sand finding its way into motors, bearings, etc. In this connection, developments by one manufacturer may prove to be a satisfactory improvement. He has placed on the market a self contained, portable, completely enclosed blaster. The nozzle of the unit is held tightly against the surface being blasted, the blasting material coming right back to the machine through a return line and then recirculated to the nozzle.

Another satisfactory method of preparation is steel grit blasting. Should a part require blasting, it is always taken to the grit blast room, if possible. Lower preparation costs are experienced when the blasting material can be recovered, as in a blast room. Most steel plants have several blast rooms. The one we use mainly is in our No. 2 machine shop at Sparrows Point which has a capacity of 5½ × 6 × 10 ft and is operated by the same man who does the metal spraying. We believe that this is a highly desirable arrangement. No one appreciates the meaning of a good surface as well as the man who has to coat it and, subsequently, do it over if the surface preparation is unsatisfactory. The size of the blast room limits its scope and we have learned that a little more money on the initial installation pays dividends in saving labor. One of our worst problems is in handling large pieces. Sometimes, we simply insert a portion of the object at a time, covering the protruding end with a tarpaulin. In turning it end for end, there is still the problem of handling it without disturbing the surface to be sprayed. A large room and a blast car on rails is just about the best arrangement.

The steel grit is angular and should be about size 30. Numbers range from 20 to 60, the higher the range the smaller the particle size. As with sand, the coarser, the better the surface; but the slower is the operation. Our practice, which is of a rather general character, is served satisfactorily by No. 30 grit.

Besides grit size, we make other provisions to insure good blasting results. We use non-static hose that is designed to ground the high electrostatic charge developed by the steel grit passing through it. High air pressure is very essential for good particle penetration and the quality of rough surface produced. Speaking of air, it is also important that a combination air filter and moisture separator is inserted in the line to prevent oil and moisture from contacting the area being blasted.

Hard brittle materials, such as cast iron and materials such as nickel steels, are very difficult to prepare by the aforementioned methods. A method of preparing the surfaces of the latter types of metals consists of applying an electrode to a surface as in arc-welding. But, unlike arc-welding, the electrode (a nickel material) seems to explode upon contact with the base metal simultaneously fusing itself somewhat as weld spatter does. The electrode is rubbed back and forth across a surface, and as contact is made and broken through the base metal, minute particles of nickel deposit themselves over the surface in such a manner that upon completion, a surface is obtained that has many irregular cavities, just ideal for metallizing. Figure 2 shows how this method prepares a cast iron surface.

Continuing our study of preparations, we shall now discuss shaft preparation. Building up shafts is probably the largest field for metal spray application. There is a right and wrong way to prepare rounds, and of course, as in most plants, we learned the right way the hard way. Most early applications in our plant were the rebuilding of press fits and bearing fits. An inferior bond is not so easily detected on this type of work, and consequently much time elapsed before failures due to poor bond became apparent.

Different vendors recommend varying procedures on shafts. All agree shafts must be undercut to insure a uniformly thick coating and to leave a constraining wall of base metal at each end of the metallized surface. After undercutting, some means for roughing the surface is required, such as rough threading or grooving and knurling. Some applications call for grit blast over top of a threaded surface, but for most of our work that is an unnecessarily expensive operation.

As for the merits of the first two methods, there are arguments either way. For conditions as they exist in the Sparrows Point plant, rough threading has proved satisfactory. In preparing shafts by these methods, at least five factors must be taken into account. First consider the shaft material, will it tear easily? Second, what metal is to be sprayed? Third, what is the shaft

Figure 4 — Internal surfaces on knife head bearings for cold strip cut-up lines are sprayed where fits are necessary.

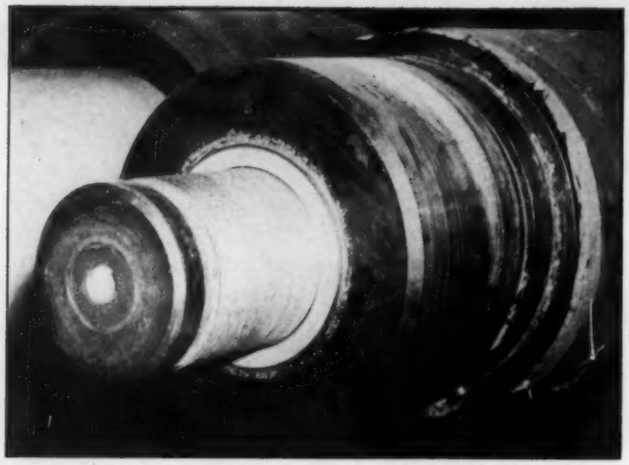


Figure 5 — Building-up of roll neck shoulders can be economically done by spraying.

size? Fourth, what is the allowable wear, and finally, has the shaft been designed to allow undercutting of its surface without creating undue stress.

Soft steel shafts lend themselves readily to rough threading, for with them it is possible to produce threads with well-torn sides that provide fins and fissures into which sprayed metal particles splash and lock themselves. A 60 degree threading tool cutting its full depth in one pass, and cutting 12 to 16 threads per inch gives a satisfactory preparation. On harder shafts, we have been obliged to thread and grit blast for best results. We do not say grooving and knurling is inferior to rough threading. We content that for our class of work it has not been found necessary. It may be a superior method on bronze and brass, however.

Metal thicknesses applied to shafts depend on type of service and size of shaft. A coating can be subdivided into several distinct zones as shown in Figure 3. One is the zone equivalent to the depth of thread. Another is a small zone just above the top of the threads known as minimum coat thickness. Wear allowance is the amount of metal above the minimum coat and the finished shaft size. Lastly, there is a zone of metal that allows for machining called finishing allowance.

Note that in preparing a shaft, it is first undercut to depth equivalent to the minimum coat thickness plus wear allowance. Of course, such designations as minimum and maximum do not imply failure if they are disregarded. They are used, more or less, to guide our shops towards uniformity. The chart shows a varying minimum coat thickness for various size shafts. This holds good except for press fits, in which cases, this minimum coat thickness is held to about 0.010 in. for all sizes. Wear allowance naturally depends on conditions of service; but we have made it a rule of thumb in our plant to limit our maximum coat thickness from the bottom of the thread to the finished size to three times the thread depth. In doing this, we avoid too thick a coating which we believe to be undesirable from a strength standpoint.

We have not found it necessary to dovetail at the ends of the threads. A well torn thread side, produced by using a negative rake on the threading tool, affords a surface for an excellent bond that in our opinion makes it unnecessary to dovetail the shaft.

This discussion on shaft preparation leads, naturally, into the question of finishing methods. So, we shall leave preparation to consider this matter of finishing sprayed metal. Unlike other materials, sprayed metal deposits are granular, more like cast metal than anything else. Thus, unless forewarned, the operator will set his tool in such a manner as to tear particles of metal loose. Experienced operators, generally, set their tools to reduce the front clearance to a minimum and, thereby, have little difficulty in turning off sprayed metal. Either carbide or high-speed tools are used, but because sprayed metals are generally harder than ordinary metal, it is found that carbide tools last longer and give higher machining speeds. It is seldom that more than 0.025 in. in all be taken off, so that the cutting tool need not be designed for deep cuts. A fairly high polish can be produced by machining as long as the metal is atomized properly, and a minimum of oxide and carbide inclusions exist. Our experience shows that among the soft steels, 18-8 stainless steel has the superior machining qualities.

Hard sprayed metals are finish ground in our plant. High carbon stainless steel and high carbon steels, in particular, are so finished. We employ wet grinding in preference to dry grinding and, thereby, keep our work as cool as we can during the operation. Care must be taken to select wheels that will not load up easily. As one would suspect, sprayed metal particles tend to clog the voids in a grinding wheel quickly. For that reason, coarse, soft, wheels are used to minimize this condition. A silicon carbide, vitrified bonded wheel is the general type recommended.

Applications of this process in our plant can be placed into several categories. We can list fits, journals, sliding members and corrosion applications.

Taking each group separately, the fit class will receive attention first. Jobs of this nature have given us no trouble. Upon cooling, sprayed metal in effect is a closely knit metallic band when applied on a round shaft. Thus, a shrinking effect takes place that actually causes the band to grip the shaft much more tightly.

Decision as to whether a press fit job is to be sprayed or welded in the first place, depends of course on the comparative costs, on the effect of welding stresses,

TABLE I

Shaft diameter, in.	Threads per in.	Depth of thread	Min coat thickness	Max coating	Finish all
1 to 4	16	0.054 in.	0.010-0.025 in.	0.150 in.	0.015-0.020 in.
4 to 12	14	0.062 in.	0.030-0.040 in.	0.180 in.	0.020-0.030 in.
12 and up	12	0.072 in.	0.040 in.	0.210 in.	0.030 in.

Figure 6 — Car axles for blast furnace ladle cars were also built-up by metal spray.

Figure 7 — Metal spray is here being applied to a gas engine piston rod.

and on the metals involved. When it is agreed that welding stresses would distort or even tend to crack a job, metallizing is strongly considered. For at the temperature the plastic metal strikes the shaft and considering its subsequent chill, not enough heat enters it to cause distortion, cracking, or to affect the heat treatment of the shaft.

Armature shafts for motors and generators are being successfully metallized with good results. On these, either a low 0.10 per cent C steel or a soft stainless steel is employed. Both are found to be satisfactory metals, chiefly because of their machinability. Another application of this sort is the knife head bearing fit for our cold strip cut-up lines. We also apply metal spray to internal surfaces where a fit is necessary. One of those applications is the shear housing bearing fit for the knife head just described as shown in Figure 4. Because, in this case, sprayed metal tends to shrink away from the base metal, it is extremely important that good preparation be made. These surfaces are rough threaded, but still do not give us too good a preparation due to the composition of the metal. We have been more successful with bronze as the spray material than with other metals in this application.

One of the more important applications is the thrust bearing fit of a back-up roll bearing for our hot and cold strip mills. We have had at least five occasions in the last few years where the neck wore down before the roll body became too small for use. We simply rough turned and threaded the necks and sprayed them with 0.80 per cent C steel and, in some cases, 18-8 stainless. We have had no failures to date on this application. Figure 5 shows a recent application. Note that metal was also applied on the face of the shoulder.

Also, in class one, we find such jobs as car axles that are sprayed with soft stainless steel and machined. One such application is shown in Figure 6, which shows axles for blast furnace ladle cars.

The second class of work is the type in which a sprayed metal shaft rotates inside a member that remains stationary. So far, there are only a very few applications of this sort in service at Sparrows Point. Some armature shafts come into this category and have worked out satisfactorily. One might also include here all applications that have fixed oil seals. Many times a metallized surface extends under an oil seal and sooner or later is subject to some abrasion.

Class three includes such work as pistons in reciprocating pumps. In our plant industrial water system, we have several reciprocating pumps that handle the activated sludge. Their 8 in. pistons were originally made of cast iron and gave short service. Upon threading and spraying with stainless steel, the pistons were salvaged and had considerably longer life. Low carbon steel was tried on this job, but was not too successful. All those with stainless (18-8) are still in service after two years. It might be interesting to note that new cast iron pistons are metallized before installing.

Another sliding type job is the gas engine piston rod. These rods are 13 ft long and 15 in. in diameter. Five have been sprayed. Our first attempts were not too satisfactory. We got into trouble on our first rod when a power failure stopped the lathe during metallizing. A blister of sprayed metal was raised and, eventually, came off during grinding. Attempts were made to recoat the one spot, but to no avail. The joint between the patch and the old metal was not sufficiently tight to chance a run in an engine. So, off it came and then the rod was resprayed. Additional rods were sprayed and were all successful but one. A 1.00 per cent C and 2 per cent Cr, $\frac{1}{8}$ in. wire was used for the coating and our records show these rods had service of over 18,000 hours. At present, two rods are in service, and have 19,000 and 3,000 hours respectively. Sprayed rods were used in both gas-electric generators and gas-blowing engines.

The unsuccessful one referred to a moment ago gave us considerable trouble, but at the same time taught us several important lessons. Following its first spraying, it was placed in service in a gas-blowing engine and after nine hours it had to be removed because of spalling at the end. Attempts were then made to re-spray and five heavy passes were applied to the rod, each 0.040 in. thick. We learned then, how not to coat a job.

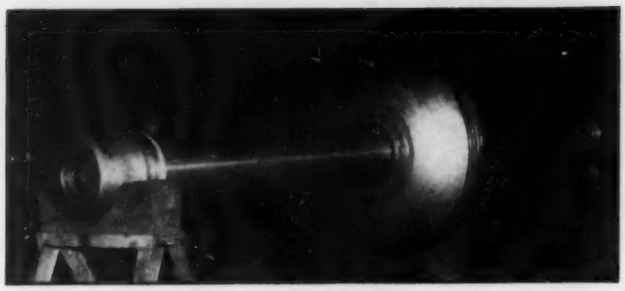


Figure 8 — Gas engine piston rod after being metallized.

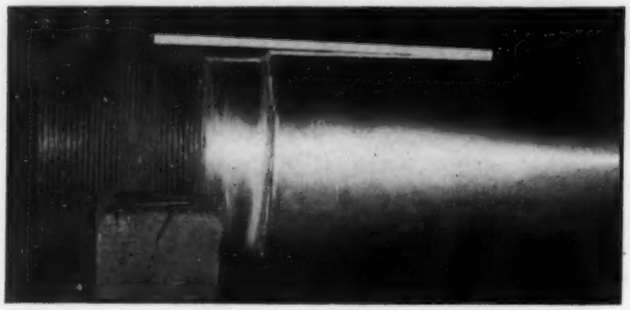


Figure 9 — When more than one layer is required in building up gas engine piston rods, metal spraying is the more economical process.

Figure 10 — This hydraulic accumulator plunger was sprayed with lead.

Needless to say, the grinding wheel peeled off five onion skins. From then on all our shaft work has been receiving from 0.0015 to 0.003 in. coating per pass and we have had no failure of that nature since. By spraying fine layers, we approach homogeneity. Lines of demarcation between successive coats should be as close together as possible, since there is an inherently greater bond strength when the coating is thin. We also found that our grooves were not quite deep enough and corrected them accordingly.

Compared with welded gas engine piston rods, we have been able to apply a harder metal by spraying and make the rods last longer. However, when rods can be given just one layer of weld metal prior to machining, we find that method to be cheaper than spraying. If two are required, metal spray costs are lower, by far. Figures 7, 8 and 9 show a rod recently metallized.

In view of other methods recently developed for rebuilding worn rods, we have hesitated to set up a metal spray shop for all these large piston rods until more is learned concerning them.

Another slide type job just recently completed is a hydraulic accumulator plunger. So far, this job has shown promise, but we cannot definitely say metal spray has solved it, yet. The plunger (26 in. diam) had worn and become badly pitted in areas along its length. Other sections showed slight wear. Packing replacement had become an expensive item and delays were beginning to creep into the picture. The alternative to spraying the surface was to erect another accumulator and use it as a spare until the first was repaired at the shop. Obviously, the cost would have been prohibitive, so that spraying was attempted during repair turns.

The shaft had to be sand blasted after de-greasing with carbon tetrachloride and then sprayed with lead to various thicknesses. Two sixteen hour periods, 32 hours in all, were required to complete this job. Lead was selected in view of its softness. We estimated the packing would last longer and that lead would be easier to dress down with a file in the time allotted. Ten days after the job was completed, spalling began and investigation indicated the sand blast was not adequate preparation for a job of this type. To this day, however, the packing has not been replaced since the failure occurred in a section of the plunger where the packing rarely comes into contact with it. We plan to make another attempt shortly, but this time we will prepare the shaft by the new electrode bond method. Figure 10 shows the sprayed plunger.

The final class of work includes those involving corrosion and erosion. These, in our opinion, are the most interesting and present the greatest savings among all metal spray applications.

One of our first attempts to combat an erosion problem was in spraying the diaphragm ledge, or retaining ring, on the last stage of a 20,000 kw turbine. Erosion brought about by the centrifugal action of the condensed steam would have continued and caused the ledge to erode away. In 1938, this ledge was sprayed with lead and partially with stainless steel after sand blasting. It has been re-sprayed once since in 1941 with stainless steel and is still doing a good job.

There are many erosion problems around pumps and many of them have been taken care of by metal spraying. Eroded elbows, cavitated nose pieces, discharge lips, and even the pump shaft, in some instances, have been brought back to size and placed back into service. In some instances, lead was used, in others, stainless steel. In 1942 we salvaged the nose piece of a 27,500 gallon per minute water pump by spraying with stainless steel. This unit is still in service after nearly five years.

Our benzol plant has a problem which bothered us for a while. We have two cast iron agitators, impeller and body complete that are subjected, alternately, to sulphuric acid and caustic soda as wash oil is being de-

benzolized. It is inevitable that the cast iron elements corrode quickly and the agitator has to be replaced at relatively frequent intervals. We have considerably lengthened the life of these units by coating with 0.030 in. of lead. Repairs are now further apart even though most of the lead eats away, eventually. It pays us to keep re-coating with lead in preference to replacing agitators.

A problem exists in our rod and wire mill billet furnace recuperators. Considerable expense is involved in replacing refractory type tubes. We have experimented with a heat corrosion resistant method patented by one of the vendors of metallizing equipment. Six inch diameter steel tubes were grit blasted, then sprayed with a high nickel-chrome alloy to a 0.015 in. thickness first and followed up with 0.004 in. of aluminum spray. Upon completion of the spray the pipe was covered with a coat of special aluminum paint. This process is supposed to withstand high temperature oxidation as high as 2000 F. It has, so far, proven successful on this job, the tubes having been recently inspected after a year's service. The recuperator temperature at the location of the sprayed tubes range from 1150 to 1325 F.

One of our most interesting heat corrosion problems is that of strip mill annealing covers, better known as inner covers. Used to completely seal steel coils as they are annealed at temperatures ranging around 1450 F, these covers must have certain qualities. They must be relatively thin to permit quick heat transfer from outside to inside, they must be leak-proof to avoid tarnishing of the steel, and finally they should have fairly long life to keep annealing costs down.

High annealing costs were directly traceable to corroded covers, ours being made of plain carbon steel. In most cases welds went bad first and the cover had to be scrapped. An average cover gave us 70 heats. This low figure was due partly to heat corrosion. If improving cover design was all that was needed, this paper would not discuss this problem at all, but since it was definitely shown that resistance against heat corrosion would pay for itself many times over on the poor design, it was logical to try it out on a new one which was in the process of construction. Figure 11 illustrates the change in cover design.

Before we describe the spraying technique, we want to introduce another variable that had considerable bearing on results. Along about the time of the first experiments, the heating furnace was redesigned from radiant tube or indirect heating to the direct heating type. Though a more economical annealing procedure, it was soon learned that an untreated cover was only good for one-half the life it could have had in the old style indirect type furnace. Thus, there was all the more reason to find a method for lengthening cover life. Our plant uses a total of 750 covers for coils and 75 rectangular covers for sheets.

Our first test was made on an old style 96 in. high cover used in an indirect type furnace. Using the only available grit blast room, we blasted it in sections, fumbling with it the best we could, and sprayed it with various known processes on different areas. One section was sprayed with 0.007 in. aluminum and coated with a solution of water glass; another had the process described above on the recuperator tubes; another section had 0.010 in. Ni-Cr alloy with an aluminum paint sealer and the fourth section had 0.004 in. Al with the aluminum paint sealer. All this work was done by hand and was laborious and expensive. Worse that that, the coatings were not uniform. However, this first cover had minor repairs at the thirtieth heat, the 78th heat and is still good after 160 heats. Remember the same type untreated cover averaged 70 heats under the same conditions.

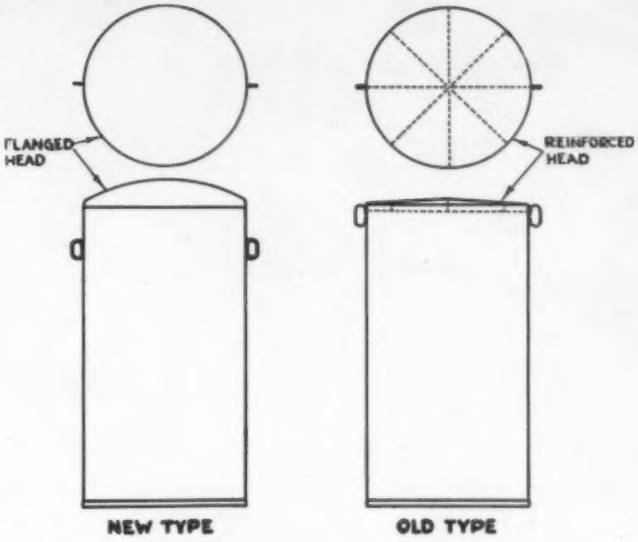
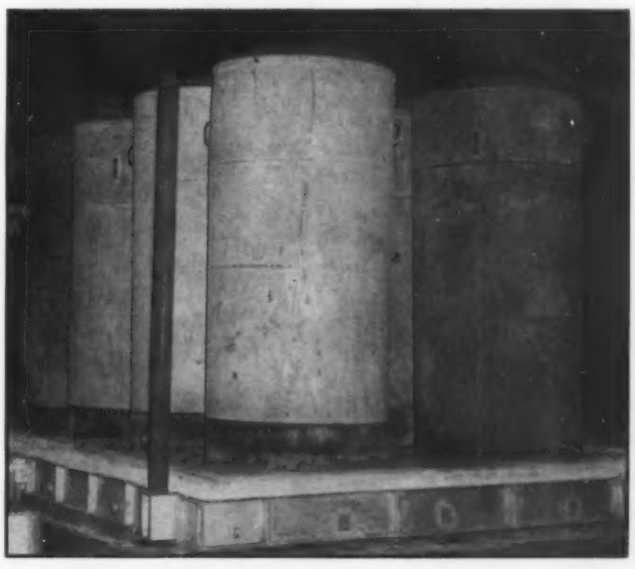


Figure 11 — Inner covers for annealing coiled strip.

It is well to note at this time that the processes in which no Ni-Cr alloy is sprayed has to be heat treated. This consists of placing the cover on a base, covering it with a hot furnace, raising the temperature to 1450 F and holding for about 20 minutes. Immediately remove the furnace and let cool.

This heat treatment causes the aluminum and iron to form a solid solution at the joint, a compound of

Figure 12 — These annealing covers have been treated by metal spraying, and it is expected that they will last 500 heats.



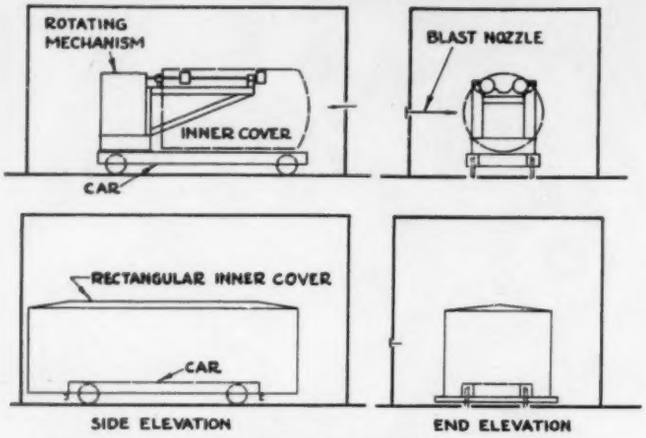


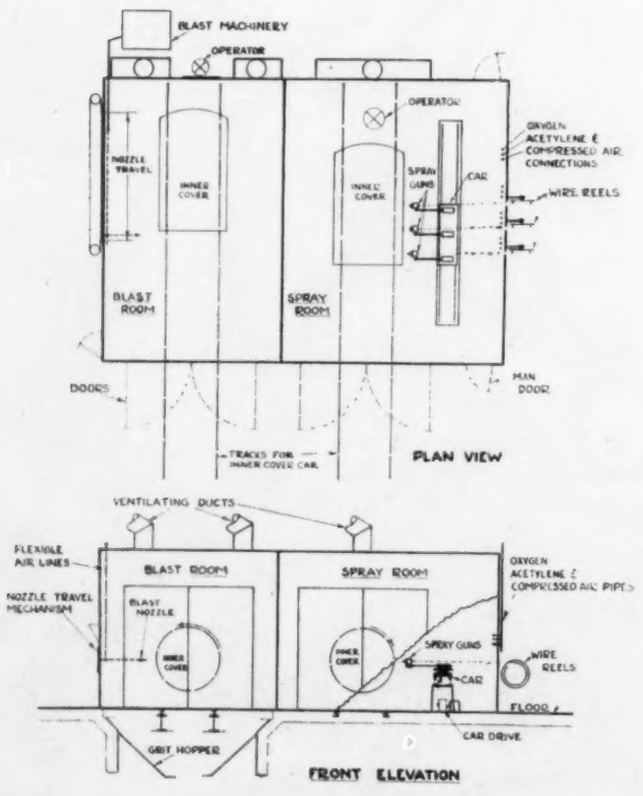
Figure 13 — Arrangement of special car for blasting and spraying inner covers.

$FeAl_3$ on top of that and an ultimate surface of excess aluminum. Thus, there no longer exists a mechanical bond but an alloy surface that resists high temperature oxidation. The purpose of both the water glass and aluminum paint is to seal off oxygen during the alloying period. These sealing media can be brushed off after the first heat.

Aside from this first cover all the rest of our experiments were made on direct-fired covers where the normal life of an untreated old type cover is 40 heats. The results of all our experiments have indicated the following and based on these findings, we are setting up a shop that will do nothing but coat inner covers. Bearing in mind, that direct-fired furnaces will be used exclusively, several conclusive statements can be made.

A ¼ in. thick dished head cover with alloy lugs is the most satisfactory design, no matter what type of furnace is used, and is good for about 90 heats, untreated. A $\frac{3}{16}$ in. thick dished head cover of the same design is good for about 50 heats, untreated. Treatment No. 1 which consists of grit blasting, spraying with 0.007 in. Al, coating with water glass and heat treating will cost about $25 per cover and will extend life about 2½ times. A ½ in. cover will last 250 heats and a $\frac{3}{16}$ in. cover about 150 heats. Deterioration comes about by slow diffusion of the iron through the coating. Treatment No. 2 consists of grit blasting, spraying 0.015 in. Ni-Cr alloy, followed by 0.004 in. aluminum and finally coating with aluminum paint sealer with no heat treatment and costs about $185 per cover. This process looks by far the best and gives us every reason to believe the ¼ in. cover will reach 500 heats. This process is particularly good on the welds. It may be possible to combine the two treatments on one cover to gain the benefit of No. 2 treatment where it will do the most good and still have a less expensive treatment over all. Figure 12 shows treated covers now in service, several of which were given both treatments.

Figure 14 — Inner cover treatment rooms.



The shop to handle these will consist of a large blast room and spray room supplied with the necessary services, air, oxygen and acetylene. Since it is necessary to avoid touching the covers on the outside after blasting, a C-hook will be used to lift the covers onto a car that has a revolving mechanism assembled on it. The car will be pushed into the room by hand. Blasting of the side will be automatic as the nozzle moves back and forth along the length of the cover. The dished head will be blasted by hand from the outside of the room. However upon completion, the entire car will be pushed out under a crane where it will again be handled with a C-hook and lifted onto a spray car that will be pushed into the spray room. There, three large spray guns will be set on a carriage and will move back and forth automatically as the cover rotates until the right amount is sprayed. An electric thickness gage will be used for that purpose. The end of the cover will be sprayed by hand. Figures 13 and 14 illustrate the method of handling.

In conclusion, metal spraying at the Sparrows Point plant has long since evolved from the cautious stage. We believe that most of the problems we have solved with metal spray were so done with the best method at hand. But we do not, for a minute, close our eyes to the fact that some work could just as well have been done in another way, perhaps much better than by metallizing. The one thing we are certain of is this, metal spray has come to stay in our plant and though we may make many mistakes in future applications, we know we have a realiable tool that has its place in the ever-growing complex field of steel plant maintenance.

DISCUSSION

PRESENTED BY

E. R. LONG, Superintendent, Central Tool Department, Bethlehem Steel Company, Bethlehem, Pennsylvania

C. C. KEYSER, Welding Engineer, Bethlehem Steel Company, Steelton, Pennsylvania

M. B. ANTRIM, Electrical Engineer, Lukens Steel Company, Coatesville, Pennsylvania

G. O. VanARTSDALEN, Electrical Superintendent, Henry Disston and Sons, Inc., Philadelphia, Pennsylvania

L. F. COFFIN, Superintendent, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

A. J. FISHER, Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

N. C. BYE, Director of Engineering, Henry Disston and Sons, Inc., Philadelphia, Pennsylvania

GEORGE MOORE, Electrical Department, Bethlehem Steel Company, Sparrows Point, Maryland

W. N. HORKO, Engineer, Henry Disston and Sons, Inc., Philadelphia, Pennsylvania

W. A. SMILEY, Electrical Department, Bethlehem Steel Company, Steelton, Pennsylvania

H. D. ESTERLY, Power Engineer, Alan Wood Steel Company, Conshohocken, Pennsylvania

A. E. CICHELLI, Lubrication Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

E. R. Long: I was very much impressed by the stress laid on the preparation of the work to be metal coated. As brought out by the author, this is a most important point, as we have found in our experience at Bethlehem. A bad preparation means a bad metal-coating job. However, in our procedure, I will first outline the cylindrical preparation.

We handle this job somewhat differently, and we have found that the preparation which we use on cylinders is giving us complete satisfaction. Since adopting this method we have yet to find a failure. We use a narrow, square-nose tool with a radius on each corner, and as I see it, we gain several advantages in using this preparation. We do not have that sharp corner to contend with nor do we run into the danger of setting up stresses at the bottom of our prepared surface. We do not cut to depths which are necessary when using the "V" tool. Our tools are made about 45/1000 to 50/1000 in. in width, usually gearing up for 12 to 14 threads per inch.

When cutting the thread we usually do that in two passes, to get a rough thread as was indicated by the speaker. We then have a narrow, flat area between our grooves. A coarse knurl is used to give it a good deep cut across the top of the thread, which prepares a very rough surface for coating. At the same time it upsets the sides of this flat, producing a natural hook to give a good bond with the sprayed metal.

After the knurling operation we are very careful to wire-brush all the loose particles from the surface and to follow this with a cleaning with carbon tetrachloride. Then the spraying operation begins and the practice from that point on is of course just about the same as that used by anyone elese in spraying the metal.

However, before getting away from the preparation, I want to outline one thing which we have experienced, and that is the fact that at the ends of our prepared surfaces we have found that by cutting a 10-20 degree dovetail, we are assured of a good tight joint at the ends. We are not too particular how wide the dovetail angle is, we only want to assure ourselves of a good tight joint. This also we learned through experience.

If the surface is smooth, particularly the surface you are trying to build up to, you will find that you are getting into a shrinkage condition which many times will lead to a bad joint. We have entirely overcome this by roughening the surface adjacent to the dovetail. In doing so, the metal will adhere to the surface and prevent a gap between the parent metal and the sprayed metal at the ends. That, we feel, has been a marked improvement on all of our cylindrical metal coating.

There was some mention made about dust accumulating, particularly when using propane. We have not used propane at Bethlehem, but dust is worrisome, particularly in the case of heavy coatings.

Our latest practice has shown a great improvement over anything in the past. We use what they call a syphon airblast and put it on diametrically opposite to the gun. A petcock permits definite control of the air from the syphon airblast, keeping the surface free from dust. Since using this device we have not encountered any peeling. I believe from what we have now learned that some of the early experiences in connection with peeling may have been due to such a dust accumulation. That, however, is only an opinion.

In regard to handling large pieces, this is a rather difficult problem, and I would like to describe a job that we have to undertake occasionally, possibly every five or six years.

We had a condition on our stacks from the gas-electric engines where quite high temperatures were involved. These stacks run anywhere from 30 to 36 in. in diameter, and from 60 to 90 ft in height. Our problem is to protect them, because there is no paint that will withstand the temperatures here involved.

At the time we started, there were no waste-heat-boilers and we were getting temperatures around the bottom of the stacks of approximately 1100 to 1200 F. From that you will readily see it was a difficult job to furnish adequate protection.

Our first stack was coated about 1936. It was set on a pair of narrow-gage cars with rollers to turn the stack. We built our blasting house to suit the job, a wooden building, rubber-lined to protect it from the blast. The shot was easily recovered. The blasting job, however, was the bottle-neck, as we could lay the metal much more rapidly than we could prepare the surface. Aluminum, in 6 to 8/1000 in. thickness was sprayed on the surface. As a result, the original stack that was put up

prior to 1936 is still in service and has never had any additional protective coating put on since.

The preparation with the fusebond unit may require a few comments. We have learned that the fusebond unit rather upsets the idea that you cannot patch metal-coated surfaces. We have found that it is possible to metal-coat a surface that might have developed a blister caused by the condition cited in the paper, a power failure.

Our first job with fusebond actually resulted from just such a condition. We were working on a job with a rather heavy coating that required two spray guns when power failure occured. Two blisters about the size of a quarter developed. The metal was then cut out at the blistered area, we fusebonded this surface, dovetailed it by hand with a diamond-point chisel, and sprayed metal in the area. The job was as nearly perfect as could be expected. It was put in service over a year ago and is still in operation.

Another application for fusebonding is on flat surfaces. From our experience, which is not too extensive, we have only had fusebond about a year, we find that it is an excellent preparation on flat surfaces. You eliminate the difficulties so frequently encountered when you cannot take your piece to the shot-blast room, as you can fusebond right on the job. With several different hook-ups, that is, with four transformer taps, various combinations are possible for controlling the roughness of your job, or the texture as it may more properly be termed. The deposit builds up to different thicknesses according to the combination of taps, ranging anywhere from 4/1000 to about $\frac{1}{32}$ of an inch, depending on the tap used. That method has worked out entirely satisfactorily up to this time.

At some later date we may be able to tell you something about the faults we have found with this method, but at present we are quite satisfied with it.

I was quite interested in the section of the paper that dealt with coatings for heat resistance, and I would like to know if the Sparrows Point plant has had any experience with temperatures higher than 1450 F. We do not do much work in this range, and we are more interested in temperatures of 1700 to 1750 F. That is the reason why I was quite interested in hearing about the nickel-chromium deposit, under aluminum.

That, I think, gives us some ideas on lengthening the life or the service of these particular pieces.

We have aluminum coated and heated up to 1850 F the bolts used in our waste-heat boilers with excellent results. They are now lasting 4 to 5 years, compared with 6 to 8 months prior to the use of aluminum-coated bolts.

Soot-blower elements are also coated with aluminum and treated with water-glass. We are getting 6 to 7 years out of these, in the back zones, while at the fire end they are lasting about two years. This type of coating has many possibilities in heat-resisting applications. I do not think we have nearly exhausted the possibilities here, partly because we have not yet had enough applications on which to try this method.

The type of work we have covered during the time we have been metal-coating takes in a rather wide range. We are almost continually coating armature shafts, propeller shafts, cross-head pins, and the like. We take our saw mandrels from the mills and recoat them, and there are plenty of roll necks and shafting of all kinds to take care of. We have also coated many piston rods, crankshafts, and so on.

I think the largest job we have handled are some hydraulic plungers. We had several of these that were about 36 in. in diameter and 6 ft in length. We coated them with 12/100 in. of stainless steel, aiming for a final coating of 8/100 in.

These have been in service for about a year, and of course we are anxiously awaiting to hear the results. This about covers our experience at Bethlehem. If I can get any more information on any higher temperatures I will be very happy. Particularly I would like to hear about your experiences with nickel-chromium under-coatings.

C. C. Keyser: At Steelton, our first metal spraying equipment was purchased in 1938 or 1939. We used acetylene for awhile, but soon changed to propane and have used it exclusively ever since. As Mr. Cichelli stated, it is a well-established maintenance tool. Certain jobs that are not practical to repair in any other way can easily be done by metal spraying making the part as good, if not better, than new. As an example of this type of repair, we had a babbitt bearing burn out on a steam turbine that drives the feed water pump for one of our central boilers. The shaft was badly scored, and being of alloy steel and integral with the rotor, welding by any method was out of the question since it would be next to impossible to get the shaft perfectly straight after welding. Another case of the same type was a hollow cast iron spindle for an automatic lathe. The bearing areas were badly worn and it was not practical to cut them undersize. Since there were several cams cut in the spindle, any distortion would have ruined the piece. Metal spraying was an easy and completely satisfactory way of repairing both of these jobs.

Before describing briefly some of the more important applications of metal spraying at the Steelton Plant, the importance of proper preparation and attention to details of the spraying procedure, as described by Mr. Cichelli, cannot be over-emphasized. Since a metal spray job, as applied to the repair of worn machine parts, is either good or bad with no intermediate quality, attention to every detail of the procedure is of the utmost importance. For this reason a good dependable operator who is interested in making a success of the process, is the first and most important requirement of a successful metal spraying program when applied to maintenance work.

By far the largest single application of metal spraying at Steelton has been the building up of gas engine piston rods, the same as shown in Figure 7, 8 and 9 in Mr. Cichelli's paper. A total of 16 rods have been sprayed, 13 of these rods have given very excellent service and 3 failed by layer separation. The way the trouble with these 3 rods developed is a good example of how you can get into trouble without suspecting it. This is how it happened.

The spraying was done in the same lathe as is used for automatic welding. When we started spraying rods, we used the highest speed of rotation we could get on the lathe with a carriage feed of $\frac{1}{2}$ inch per revolution, which was the maximum feed, the idea being to get the thinnest deposit per layer. We had no specific thickness

of layer in mind but the first rod was sprayed with 11 gage, 1.20 per cent C wire at a rate of about 2½ lb per hour. This produced a layer that was plenty thin and did a fine job. As we gained experience, changed from acetylene to propane and from 11 gage to ⅛ in. diam wire, our melting rate finally reached between 6 and 7 lb per hour, with everything apparently going fine. Then we sprayed a 9 in. diam piston rod and when it went to the shop for finishing, it could not be ground at all, the sprayed metal peeling off in layers under the grinding wheel. This of course told us we were getting the layers too thick. At about this same time, the three most recent rods we had sprayed started to fail by layer separation after being in the engines 7200, 5831 and 696 hours. Changes were immediately made in the lathe drive to get sufficient speed to produce layers less than 0.002 in. thick with the result that no trouble has been experienced from layer separation since. The 13 good rods have given excellent service, 5 of them are still in service and up to January 1, 1947 had 53,000, 29,500, 29,400, 15,800 and 14,500 hours of actual operating time. The 8 rods that have been removed from service gave the following: 38,900, 38,300, 31,900, 30,900, 25,200, 20,800, 19,100 and 12,800 hours of actual operating time. When it is remembered that between 6000 and 7000 hours constitute a year, the sprayed rods are doing very well and on the average giving better service than new rods.

Another very successful application of metal spraying has been the building up of exhaust valve stems for the gas engines. The sprayed area is about 16 in. long by 4⅝ in. diameter. The stem is sprayed and finished without any ring or oil grooves as shown in the drawing. The average life of a new valve is 6746 hours at which time, it must be reconditioned. The average life of metal sprayed valves is 14,647 hours. During the past several months, two valves with sprayed stems have been removed, due to bad seats, with 21,000 and 24,000 hours of service and the stems are still good for another run.

Another rather severe application of metal spraying was the building up of the wearing surface of brake wheels fabricated from mild steel plate. These wheels gave excellent service except in the most severe location. However, this application has been discontinued in favor of surfacing the fabricated wheels with hard metal and grinding to finish size.

The wire mill at our Williamsport plant has made several very successful applications of metal spraying. The cast iron capstans on the wire drawing machines get a groove worn in them where the first and second turn of wire comes in contact with them. The worn area is undercut to a depth necessary to remove the groove that has been worn in the capstan, and after preparing the surface by grooving and knurling and in some cases, with the electric bonder, the job is built up with 1.20 per cent C wire and ground to size. These metal sprayed capstans have given much better service than new ones. The step cones on the Vaughn, high speed machine for drawing fine wire, are built up in the same way and are giving excellent service. These are built up with No. 2 stainless wire since they operate under a spray of cooling solution.

In Steelton, as at Sparrows Point, metal spraying is a well-established and valuable maintenance tool.

M. B. Antrim: Possibly Mr. Cichelli has had some experience which he would care to relate with the preheating of certain jobs such as inside surfaces which would reduce the shrinkage problem encountered on metal spraying applications.

We should also like to know more about this so-called "sputter" job of bonding.

We are also greatly interested in the higher temperature applications, or refractory use, of metal spraying. For instance, we are from time to time troubled with annealing furnace stands, on which is placed the metal to be annealed. At present these last only a short number of heats. Perhaps this method could be used to prolong their life.

G. O. Van Artsdalen: My first question is in reference to that accumulator rod that was built up using a lead coating, and I would like to know what the life of a lead coating would be there in comparison, for example, to a stainless steel coating or some harder metal. Was he just thinking of saving of the packing? What was the purpose of a lead coating?

Another question was with reference to the "sputter" coating or preparation which I believe is very comparable to arc welding except that there is little deposit left. Is it just a roughening of the surface with the arc? After the roughening-up takes place must that surface be sand-blasted or prepared to get rid of the smoke deposit, flux, etc.?

L. F. Coffin: The advantages of this process can best be made use of in connection with the maintenance machine shop in the steel plant, where you have these tools and other methods of repair such as welding, brazing, and chrome plating. Thus, you can use the particular process that is best suited to that particular job.

A. J. Fisher: I would like to elaborate a little bit on the economic background of these annealing covers as illustrated and told to you by Mr. Cichelli. We at Sparrows Point have about from 900 to 1000 of these inner covers in service at the present time and these covers can be made out of four materials. One of course is alloy, approximately 18 chrome, 8 nickel; another can be made out of chrome-nickel clad on steel; the third class is metal spraying, of which Mr. Cichelli has told you; and the fourth class is plain carbon steel.

Alloy inner covers cost about $1500 apiece. You can see if you multiply 1000 by 1500 you get into quite large sums on which the interest is quite high which tends to throw us down into the cheaper grades for cheaper cost. A clad cover would cost about half as much as the straight alloy cover, and the sprayed cover that Mr. Cichelli has told you about is very little more costly than the mild steel cover. I think the ratio of $85.00 or something like that for steel and $25.00 for metalizing with aluminum, which is approximately $100 to $150 per cover depending on the treatment used.

So we are bent upon metal spraying of these inner covers and are spending under Mr. Cichelli's direction $50,000 on a new metal spraying plant for inner covers.

We have an application for inner covers in which the temperature is around 1750 F. That is in the wire mill annealing department which is a rather small application involving maybe around 15 or 20 inner covers. We are now using alloy inner covers at the present time — 18-8 grade, and we are hoping as Mr. Cichelli gets

along in his work, he will tackle one of these higher temperature jobs. I am sure with his training and the help of the gentlemen that have spoken here tonight, he will be able to get away with that job also.

N. C. Bye: I would like to ask Mr. Cichelli what his experience has been in building up shafts where taper fits and keyways are involved in the built-up areas.

George Moore: It appears the majority of firms represented here are using metal spray apparatus to good advantage, and I should like to inquire if it is practical, with improved methods of preparing shafts, to metal spray tapered pinion fits on armature shafts where the keyway is cut through the sprayed material. At present, in our electrical repair shop at Sparrows Point, any job we want to metal spray must be sent to No. 2 machine shop where the equipment is located. This is a distance of about 1 mile from the electric repair shop. It makes an awkward situation and we should definitely make more use of this method if we had apparatus conveniently located in our own shop. It has, therefore, been necessary for us to adopt other procedure for taking care of the jobs which otherwise would be metal sprayed.

E. R. Long: In answer to the question about fuse-bonding, I wish to state that I had the final preparation in mind. The only thing that we do beyond that is to take a wire brush and go over the area and clean it with carbon tetrachloride. It is then ready for spraying. Now, in connection with the laying of metal on shafting with keyways, we have had considerable experience along that line with the method of preparation that I have outlined as followed at Bethlehem, using a square-nosed tool with the radii in the corners. We very easily hook the metal in and have no danger of pulling it away where a keyway is involved. In such a case we place a wood block in the keyway after it is threaded, which prevents the metal spray from going down into the keyway. The block is very easily removed after the spraying operation is completed, by driving it out in the same way as the key. The metal will hook in right up to the edge of the keyway.

W. N. Horko: I have a question I would like to ask. Mr. Cichelli mentioned the detrimental effects of the oxides and the carbides which might be included in the spray material. I am wondering how an operator can tell whether his spray is on the oxidizing or reducing side, and just how he would control it.

W. A. Smiley: The subject of surface preparation has been very thoroughly developed by Mr. Cichelli and we are in agreement with his views in the matter, although we sometimes use other methods to meet particular conditions.

When the surface has been rough threaded, or grooved and knurled, the results secured by the machinist are not always as satisfactory as may be desired. To meet this condition we have found that the use of "spatter-weld," employing nickel or nickel-alloy rods, generally produces a very superior surface to receive the sprayed metal. The use of "spatter-weld" has been described previously in another form of surface preparation, but I do not recall that the importance of cooling the weld rod, with a strong stream of air, had been mentioned.

Steel which is, or has been, greasy will sometimes exude oil under the heat of spraying. If the piece is baked at a temperature which will volatilize or carbonize the absorbed oil, this trouble may be averted. We feel that naphtha is preferable to carbon tetrachloride for removal of surface dirt and oil, not only on account of absence of later corrosion, but also on account of the toxic character of carbon tetrachloride. We have been informed of one fatality caused by this material, and have had direct evidence of the hazard attending its use.

In connection with the problem of oxidation or corrosion of the surface, we would like to know what, if any, influence proximity to the ocean and "salt-air" may have on the time allowable between preparation and spraying.

The problem of eliminating dust, be it carbon or metal dust, from the surface being sprayed has been discussed with means for its elimination. We have found this does not constitute a problem when a certain kind of spray gun is used by a thoroughly competent operator using propane gas as fuel. The forceful blast produced, using propane gas at high pressure, would further serve to dislodge any dust which may be present due to improper adjustment of the gun by the operator. We concur in the opinion expressed that it takes a more highly skilled and more attentive operator to use propane gas successfully than is required by acetylene gas, but find that the greater density of deposit produced by the propane gun warrants the extra care. In addition we enjoy the cheaper cost per pound of metal deposited.

It may be of interest to some to know that low tin solder (35 per cent tin, 65 per cent lead) may be applied to steel, as an anti-rust coating, by spraying directly onto a sand blasted surface and later flowing the sprayed solder by application of heat. No difficulty has been experienced in securing alloying action although no flux is used.

H. D. Esterly: Are there any fumes encountered with metal spraying, and if so, how do they affect the operator?

A. E. Cichelli: I think we can summarize by saying that evidently there is much difference of opinion among the various companies.

Some prefer grooving and knurling to rough threading. Where this preference prevails, the former method has given good results, whereas attempts at rough threading were found to be inferior.

I am afraid the results in our case were just the opposite. Originally, we prepared shafts by grooving and knurling and subsequently ran into trouble. We can attribute our trouble in using this method, somewhat to the fact that when a surface has been so prepared, the lands between the U-grooves are rolled over leaving what amounts to an overhanging ledge. Unless the operator is careful in spraying under those projections, he may leave voids beneath them that will cause just as much trouble as the sharp thread, which is of such concern to those who dislike the rough threading method. In fact, we have had no failures on shafts at all once we went to rough threading. Prior to that, there were several instances of bond separation.

Wire-brushing was mentioned. Yes, we do wire-brush

to get rid of loose particles. Carbon tetrachloride also is used when found necessary.

Roughing a surface adjacent to sprayed surfaces is good practice that we try to follow on shafting. We do not find it necessary to dovetail. By rough threading, we seem to achieve a bond sufficiently strong to preclude end-dovetailing.

The subject of dust came up during discussion. Carbon dust was pointed out to be due primarily to improper setting of the flame. There is present also some metallic dust that consists of particles that cool too rapidly for impingement on a surface. This is dust that I think you can discount. The dust we are worried about is that from the oxy-propane or oxy-acetylene flame. With proper flame setting, there is no difficulty. Mr. Horko brought up the question as to how can an operator tell? Proper instructions is one of the functions of a supervisor. Not only the operator, but the supervisor also has to know when the flame is neutral. With a neutral flame one minimizes the formation of dust. The difficulty with propane is that it is harder to see a neutral flame. As you know in a neutral flame, the primary and secondary zone cones are clearly defined, there being no intermediate zone.

I was interested in Mr. Long's comment about patching surfaces with the electric-bond methods. We have not tried it as yet. It sounds like a very commendable practice. We shall have to try it when we come across a surface that lends itself to patching.

There was a question as to whether we had any experience with the heat-resistant and anti-corrosion method at higher temperatures. We have one application that is at a slightly higher temperature than those I have mentioned and that is in our hot strip mill slab heating furnaces. We just had to see what the coating would do and so we coated two skid pipes. The one was a cross and the other a longitudinal skid. The temperature of the furnace is over 2300 F. Of course the pipes have water running through them and therefore the exact temperature of the surface of the pipe is undoubtedly under 2300 F. We inspected the pipes after about 8 months' service and found the coating to be still intact.

A question was raised by Mr. Antrim as regards preheating jobs. We have not had any experience as yet, but we have been contemplating it for some applications.

Mr. Smiley pointed out unless you have air directed on the electrode in the electric bond method it is of no value. That is perfectly true because the electrode becomes so hot it will just bend and be useless.

One company has a clamp holding six electrodes in one holder. Their competitor has a holder for a single electrode but they both do the jobs that they claim they can do.

Mr. Van Artsdalen, in the case of the plunger, we selected lead at the time since we did not have very much time allotted us to do the job, and we had to dress the surface down in a hurry. Now, if we had that job to do in the shop we would rough thread it and apply stainless steel on it.

As pointed out in the paper, we hope to do it again and use the electric bond method of preparation and do it in sections. I believe Mr. Long answered your question as to whether electric bonds had to be sandblasted.

Mr. Coffin remarked that the place for a spray gun is in a maintenance machine shop where it will do the most good. We have one in our machine shop now, and we shall have more of course in the shop that we are now building to coat inner covers. This set-up gives us a wider range of flexibility in our maintenance work.

Concerning Mr. Fisher's remarks about wire mill annealing covers, let me say that we have already arranged to take care of those covers as soon as we are set up. I think we can handle it.

Mr. Bye asked about our experience on tapered fits. Yes, we have had one, but not too happy a one. That does not mean it cannot be done, but in our particular case we tried to do it on a feed reel cone hub for coils. A nut holding the assembly together loosened and the subsequent pounding was too severe on the coating.

As to keyways, I believe that has been answered by several people. I will say this and I am afraid it is in contradiction to some of the statements already made. Every one seems to have the thought and the idea that one has to be very, very careful with metal spray. It is something delicate, that one can not mishandle, and so on. Now, we do not want to leave that impression at all. As far as keyways are concerned, I know we use wood blocks at times, sometimes carbon paste, sometimes nothing, and we get away with it. For our part, we do not find keyways a serious problem.

I was interested in the application of spraying tin and lead solder, and the fact that Mr. Smiley obtained an alloyed bond. I want to thank him also, for bringing out the fact that in the use of carbon-tetrachloride, one must be careful in regards to caring for the operator's safety. We do not use it in large quantities, but generally use a little brush and touch up the surface with it. Subsequent corrosion from use of carbon-tetrachloride is something to be concerned about and more so if the job is allowed to lay around. In this respect, no time is wasted in our plant. We do not know of a failure, attributable to carbon tetrachloride corrosion. In regards to sprayed piston rods, there is something that perhaps I should have mentioned. The high hours on piston rods are not just due to metal spraying, but due to good packing and lubrication. But it is true conversely, if the metal spraying is poor, it is immaterial how good the packing and lubrication are, the rod will fail.

Mr. Esterly asked a question about fumes. In spraying steel there are few fumes. There is metal dust of course. If one is around a job very long he will find he has acquired by a dry feeling in this throat. That comes from inhaling this dust. We do not find it injurious unless one is exposed to it all the time. Then, we have respirators. You notice the man on the screen was not using one. He was spraying steel. But when a metal like lead or any metal containing lead or zinc is sprayed, we insist on their wearing some protective equipment. This new shop we are building will also have fans for taking off the fumes.

SURFACE PREPARATION OF SEMI-FINISHED STEEL

. . . . the mechanical chipper is a production machine and should be used as such . . . . best economies are attained on billets larger than 4 x 4 in. and longer than 5 ft . . . .

By JOHN W. DEIMLER
Electrical Engineer
Alan Wood Steel Company
Conshohocken, Pennsylvania

▲ WE are all aware of that necessary evil, surface preparation, in the production process of steel, and it is not necessary to elaborate any further on this phase of the subject.

This paper will deal with the mechanical or machine method of billet chipping. This machine is used to eliminate, to a great extent, the old hand chipping method of preparing billet surfaces. The type of steel which can be successfully handled, whether it be plan carbon steel or alloy steels, will be, in general, the same for the machine as for hand chipping. The type of cutting tool would be the only change necessary.

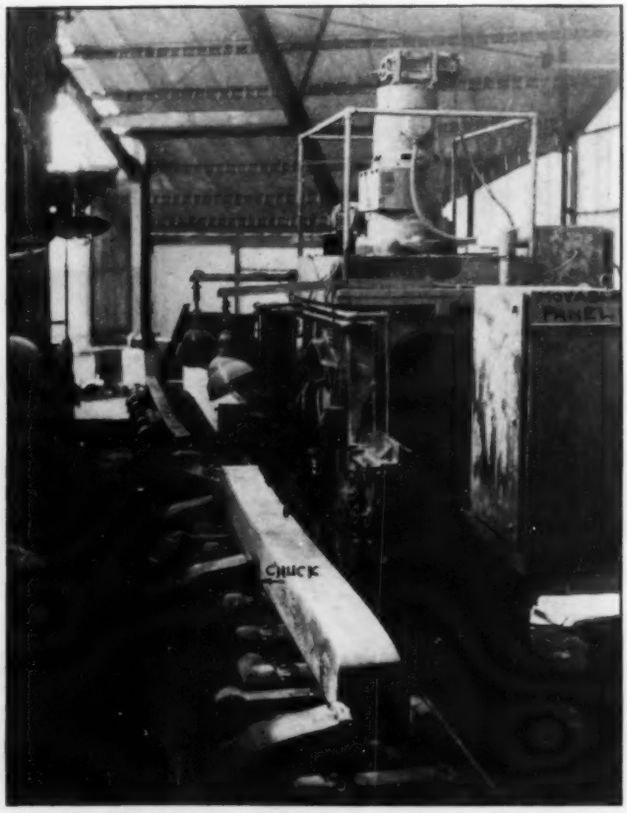
The mechanical chipper consists primarily of three parts, namely: the feed skids and feed table, the cutting table and chipping machine proper, and the runout table and skids. All the tables are, of course, roller type and are in the same line. The feed skids provide a storage space for a supply of billets which are to receive surface preparation. The billets are moved onto the feed table by means of a pusher and thence to the cutting table. The cutting table is equipped with auxiliary equipment such as a stop, chucks, and the cushions. The runout table receives the billet after chipping has been completed and a pusher moves it onto the skids for future removal. See Figures 1, 2 and 3.

The main part of the machine is the chipper itself which moves on a carriage for the full length of the cutting table. This is about 26 ft for the "C" size machine and 19 ft for the "B" size. Carriage speed is 17 fpm feed, and 34 fpm return. All the controls for the operation of the entire unit are on this part of the machine so that they are always within easy reach of the operator. A joy stick type of switch controls the movement of the carriage along the table and the elevation of the tool head. This provides a very flexible control for the movement of the unit. The tool head is moved in and out by means of hydraulic (oil) pressure. The speed of the tool head is controlled by a drum switch which provides three speed operation.

Auxiliaries on the cutting table consist of air operated chucks for holding the billet, hydraulic cushions for absorbing the shock when the billet is turned over, and a stop for backing up the billet. Our chucks are 3 in number and set 70 and 93 in. apart, with cushions in between.

The tool head usually consists of eight cutting tools and operates at 12 rpm. This means that a skilled operator can make as high as 96 cuts per minute. At our

Figure 1 — Billet is shown on cutting table held in position by chucks. Billet in rear is on the feed table.



Presented before AISE Philadelphia District Section Meeting, December 7, 1946

Figure 2 — This view shows the tool head, stick control, and push buttons for the control of all the auxiliary equipment.

plant we use a high speed steel cutting tool 2 in. wide × ¾ in. thick × 8 in. long with a 2½ in. radius on the cutting edge. This tool is heat treated by quenching at 2350 F and drawing at 1050 F for 5 hours, and is obtained from the machine builder. This tool is used for all our chipping operations, regardless of the analysis of the steel.

The size and length of billet which can be handled on this machine varies somewhat in the individual plants. At our plant on the "C" size billeteer, we chip sizes ranging from 4 × 4 in. to 12 × 12 in. and 7 ft to 26 ft 3 in. in length. A billet as long as 17 ft 6 in. can be set up without the necessity for turning it end for end and the cutting table stop is used. For pieces longer than this, an auxiliary stop set in the feed table section is employed, and the billet turned end for end to complete the cleaning operation. On the "B" size machine, the same size range is handled but the length is from 5 ft to 12 ft. This length can also be increased by employing an auxiliary stop. The governing factor which determines the size billet which can be handled is the chucks. At another plant I know of, a special chuck adapter is used for 5 × 5 in. squares and 14 × 14 in. square is the largest size which can be handled.

The speed at which surface preparation can be accomplished is dependent upon a number of variable factors which are difficult to evaluate. Perhaps the one which affects production most is the amount of cleaning which has to be done on each piece. This factor alone is influenced by many conditions such, as the analysis of the steel, type of ingot (hot top or bottom cast), rolling conditions, and ultimate use.

The production of our "C" size machine is about 4½ net tons per machine hour and about 40 per cent less for the "B" size machine. Normally the "B" machine is used to clean the shorter lengths of 4 × 4 in. and consequently its production rate is considerably lower than that of the larger machine.

To illustrate the effect that short lengths have upon the production rate, the following table will illustrate some average conditions. In order for the two machines to produce the same tonnage, the number of cuts and turnovers as shown on the table would have to be made for each machine.

Machine	Billet size	No. of cuts	No. of turnovers
B	4 x 4	20	60
C		8	24
B	6 x 6	8	24
C		4	12
B	8 x 8	4	12
C		2	6
B	10 x 10	3	9
C		1	3
B	12 x 12	2	6
C		1	3

Actual set-up time is relatively short regardless of billet size or length. Cutting tool changes can be made quickly if the tools and tool supports are set up in a gage with the necessary shims. The tool and holder are then inserted in the head as a unit and need no further gaging.

The drives for this machine are electric motors which, in most cases, have to be reversing (runout pusher excepted). The quick operation made possible by the joy stick control imposes an extremely high duty cycle upon the carriage and elevator driving motors. These motors are regularly expected to start and stop as high as 60 to 70 times a minute for several consecutive minutes. The tool head motor, while running continuously, is subjected to repeated peak loadings during the cutting operation. Forced ventilation is provided on the carriage and elevator motor.

The control panels for the unit consist of a stationary panel located near the machine and a panel mounted on the moving carriage. Push-button operation is used as extensively as possible.

While the total connected horse-power is rather large, being 111 hp for the "C" size, the maximum used at

Figure 3 — The back view of the billeteer shows the carriage and the drive motors.

any one time is 53.5 hp when the tool head and carriage are operated simultaneously; these being the largest motors on the machine.

There has been considerable controversy as to the most desirable electrical characteristics of the motors and controls. With no intention of becoming too involved in any discussion of this subject, I would, however, like to make some comments on this subject. The duty cycle imposed on the carriage, tool head, and elevator drive is so severe that any motor other than a d-c motor is likely to fail in service. This has been the experience in one instance that I know of. As for the other drives, such as the pushers and tables, they could be a-c or d-c.

The control panel on the movable carriage is subject to excessive shock and vibration, particularly after the machine has had some years of service. I believe great improvement in the reliability of operation and reduced maintenance can be obtained by removing this panel from the machine. The number of conductors in the flexible cable necessary for electrical connections between the carriage and the control panel will be increased somewhat because of the extra power leads to each individual motor, but cable will require less frequent attention and is easier to replace than are the contactors in the panel. For the high number of repetitive operations, it would also appear advisable to use d-c for the control circuit of the panels.

The machine chipper is primarily a production machine and will give the best results only when used as such. When this machine is used to work short lengths and smaller sizes, the cost of operation increases rapidly as is evident in the case of our "B" machine. It would appear that any size below 4 × 4 in. and shorter than 5 ft lengths cannot normally be cleaned economically on a machine of this type and hence fall into the category of hand chipping.

DISCUSSION

PRESENTED BY

L. F. COFFIN, Superintendent Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

W. N. HORKO, Engineer, Henry Disston and Sons, Inc., Philadelphia, Pennsylvania

J. W. DEIMLER, Electrical Engineer, Alan Wood Steel Company, Conshohocken, Pennsylvania

L. F. Coffin: Is not the yield from a billeteer lower than when hand chipping is used?

W. N. Horko: What is the loss of steel, with the use of a billeteer, as compared to the loss with hand chipping?

What is the approximate floor space required for these two machines?

J. W. Deimler: With an experienced operator I would say that there would not be any appreciable difference in loss of metal with the machine and hand chipping. It would depend entirely on how accurately the operator gaged the depth of his cut at the increased speed of operation and also how far along the crack or flaw to cut.

The approximate floor space required by the "C" size machine, which is the larger of the two, would be sixty-five and a half feet by eighteen feet for the machine proper and in addition, a twenty-six foot long by four foot deep working area would be required for your machine operator and an inspector if you inspect the billets on the cutting table and do not have a separate inspection area.

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SEPTEMBER 28, 29, 30 AND OCTOBER 1, 1948

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND, OHIO

FLAME DESEAMING

. . . . torch deseaming offers possible cost advantages, particularly where the defects are deep or where 100 per cent skinning is necessary . . . .

By FRED JUDELSOHN
*Lukens Steel Company
Coatesville, Pennsylvania

▲ AT Lukens Steel Company, only plate is rolled. Use of the deseaming torch started in 1929, on common steel only. Since then, we have increased its use to all steels which we make. This includes steels up to 0.45 per cent carbon and various alloy steels.

In order to present a picture of the work we are doing, we will start with rimmed steel in ingot form. The analysis of this steel is: 0.11 to 0.30 per cent carbon, 0.31 per cent manganese, 0.010 per cent phosphorus, and 0.03 per cent sulphur.

The ingots are received in the steel yard and are laid out in rows. The fins and runners are removed with the deseaming torch. We have found the deseaming tip to be much faster and more economical for this work than the standard flame cutting tip.

We have developed a method for testing the condition of the rim, so we are certain we are making the highest quality rimmed steel possible. Every ingot in each heat is tested by making a groove about ½ in. deep along the length near one corner. The groove is made with two passes of the deseaming torch. Thus we assure ourselves that the rim of each ingot is of high quality before it is rolled into plate.

The sizes of the rimmed steel ingots will vary from 32 in. wide by 12 in. thick, to 54 in. wide by 23 in. thick; and the weights from 3000 lb to 25,000 lb.

High carbon steels, over 0.30 per cent carbon, and various alloy steels are deseamed at a temperature of about 400 F. The alloy steels are then either piled together to keep in the heat, or are put into reheaters for slow cooling or post-heating. Some of the nickel steels are first descaled by bobbing so the defects may be seen, and then are deseamed with the torch.

COSTS

Because of the varying factors in every plant, the dollars and cents cost figures are not very good to use in trying to compare the cost of an operation in one plant with an operation in another plant. For this reason, this discussion will be limited to some of the factors which affect costs.

Usually, when deseaming is first introduced into a plant, it is performed on work that is impractical to do with hand chipping. In other words, on steel which probably would have been scrapped. When the differences of the methods are appreciated and deseaming is considered for the overall job, then, in the majority of cases, deseaming will have many advantages over any other method of surface preparation.

Torch deseaming is generally cheaper; the greatest savings being made where the defects are deeper, or where 100 per cent skinning is necessary. This cost advantage will vary greatly with the depth of the defect and the grade of material. Chipping costs go up very rapidly as the depth of the defect increases, and it is more difficult to chip alloys and higher carbon steels than low carbon steels. Deseaming costs do not go up nearly as rapidly as the depth of defect increases, and

Figure 1 — The operator is removing fins and runners, and grooving for a rim test.

Presented before AISE Philadelphia District Section Meeting, December 7, 1946

*Now with Air Products, Inc.

Figure 2 — Close-up of groove for rim test.

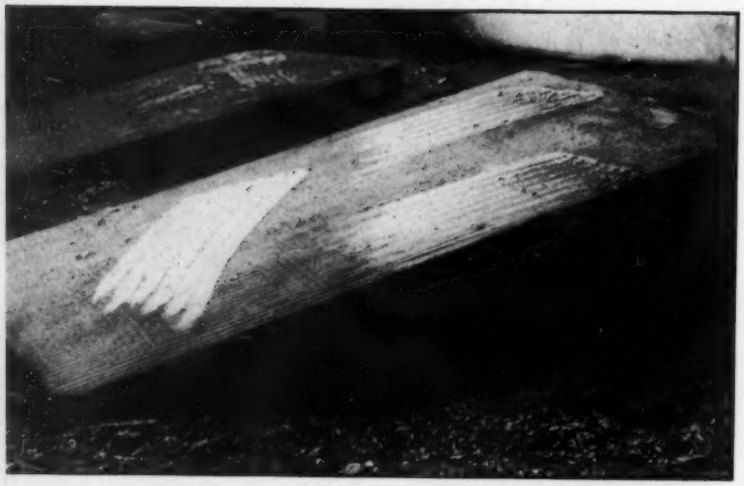


Figure 3 — Spot deseaming only was required on this slab.

Figure 4 — The appearance of a large 60,000 lb slab which had 100 per cent skinning is here shown.

actually, the higher carbon steels can be deseamed more rapidly than the lower carbon steels. These savings permit a broader application of deseaming than chipping. Much material can be reclaimed that otherwise would have to be scrapped on account of the excessive cost of other surface preparation. Another advantage is that steel can be deseamed before it becomes completely cooled, thus eliminating mill delay.

Deseaming is much faster than chipping. Speeds of 30 to 50 feet per minute are usual. The cut is from 1½ to over 2 in. wide and from ⅛ to 3/16 in. deep. One deseaming operator can equal the work of 6 to 10 chippers. This means that special orders can be moved faster, with less space required. A much smaller conditioning force is required. With present day labor and overhead costs, this is a very important factor.

Deseaming is a more thorough method of removing defects, particularly where they are in the form of small cracks when 100 per cent of the surface must be skinned. The heat of the operation shows these cracks as white lines, making them plainly visible.

Defects should be properly marked by inspectors so they may be plainly visible through the operator's dark glasses. This would minimize the waste of gases and labor by eliminating the necessity of removing the glasses in order to see the defect. A yellow crayon is preferable to white chalk for this marking.

APPARATUS

For spot deseaming and 100 per cent skinning, we use a deseaming torch equipped with a starting rod attachment. This attachment feeds a 3/16 in. steel rod, about ⅜ in. at a time, under the preheating flames for each start. This enables us to get fast starts without deep gouges. For removing fins and runners and for rim testing we use a torch without the starting rod attachment. The tip used has a bore of about ⅜ in., and the oxygen pressure is 95 lb in the oxygen line. We do not use oxygen line regulators with this torch. The oxygen consumption of the tip is about 4500 cfhr. As the oxygen demands for deseaming are high, adquate supply and proper size pipe lines are essential.

TRAINING OF OPERATORS

In selecting the proper personnel for deseaming, it has been found that young, loose-jointed individuals make the best operators. As a rule, chippers do not make good deseamers. They have preconceived ideas about defect removal which may be entirely wrong from the standpoint of deseaming. If a choice is possible, an entirely "green" man is preferable to a chipper or even to a man experienced in flame cutting. Some individuals learn the process faster than others. At our plant, a man is classed as a beginner for the first six weeks; then as a second-class operator for the next two months; at the end of which time he becomes eligible to be rated a first-class operator.

In summation, we might say that nearly all steels can be, and are being, deseamed successfully, provided the proper preheating and post-heating are done, when required. The process, in most cases, has proven to be

more economical than other methods of surface conditioning semi-finished steels. The comparative costs will depend largely upon the method of set-up, training, and other controlling factors peculiar to each plant. There is no doubt, if it had not been for flame deseaming, we would not have been able to produce the large quantities of steel in the required time during the past war years.

DISCUSSION

PRESENTED BY

L. MORRIS, General Foreman, Bethlehem Steel Company, Sparrows Point, Maryland

A. E. CICHELLI, Lubrication Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

C. M. FITZPATRICK, Assistant Superintendent Blooming Mills, Bethlehem Steel Company, Sparrows Point, Maryland

W. N. HORKO, Engineer, Henry Disston and Sons, Inc., Philadelphia, Pennsylvania

FRED JUDELSOHN, Lukens Steel Company, Coatesville, Pennsylvania (now with Air Products, Inc.)

J. W. DEIMLER, Electrical Engineer, Alan Wood Steel Company, Conshohocken, Pennsylvania

LOUIS MOSES, Superintendent Rail Mill and Roll Department, Bethlehem Steel Company, Sparrows Point, Maryland

C. R. HAND, Assistant Superintendent, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

L. Morris: Mr. Judelsohn, I do not believe you mentioned the type of gas you were using.

A. E. Cichelli: I also had the same question. I should like to add however, in the event, the answer is natural gas, has the author compared its cost with acetylene scarfing or coke oven gas scarfing?

Another question I had in mind refers to the type of tip used. Does it have a skirt or counter-bore? If so, does it become clogged?

Please explain the term, "bobbing." I am not familiar with it.

C. M. Fitzpatrick: I wanted to ask one question, was the author using a single tip or multiple tip torch on that operation?

W. N. Horko: Just as a matter of interest, I would like to ask what was the pressure in the natural gas line?

Fred Judelsohn: Our natural gas line pressure comes into the plant at about 100 psi and we reduce it to about 45 psi. The pressure used at the regulator that is supplying the torch is about 20 psi.

W. N. Horko: I would like to corroborate some of the statements Mr. Judelsohn made regarding the speed of scarfing as compared to other methods of surface preparation.

Recently we made a test to determine the difference in the cost of scarfing as compared to grinding, and we found that the cost ratio was about three to one in favor of scarfing. We also found that the time ratio was about 19 to 1 in favor of scarfing. We have ordered some scarfing equipment, and while we do not expect to maintain the 19 to 1 ratio, we do think there is going to be an appreciable saving. Is there very much spoilage when you break in a new man?

J. W. Deimler: I would like to hear some discussion on what effect the hard skin you get as a result of scarfing would have on future processing of the steel.

Louis Moses: I have a question concerning the hot scarfing of billets. It is known that a large producer of upsetting grade bar stock found difficulty with the flash adhering to the edges of a pass made by the torch. The flash was completely decarburized, and did not scale off in the reheating furnace, appearing as residual streaks in the rolled bar. Because of this it is understood that some producers favor the mechanical chipper or deseaming by the probably more expensive grinding process. I would like Mr. Judelsohn to comment on this.

Another question concerns hot scarfing of high carbon steel where it is understood a cracking or shallow shattering occurs on the scarfed surface.

C. R. Hand: How much cheaper is it to scarf with natural gas a fuel than it is with acetylene?

Fred Judelsohn: Lukens Steel Company many years ago used acetylene entirely. It goes back to the old story of what are you doing in your plant, and how much of it are you doing, and how much of a commodity are you buying, and what are you paying for that commodity, how much your labor costs you per hour, and what is your overhead.

Let us take the commodity. If you own a little garage and you buy one cylinder of oxygen a week, you are paying around $1.60 a hundred cubic feet for your oxygen. If you are running a steel mill like the Lukens Steel Company and you are using millions of cubic feet of oxygen per year, you can very readily see that the oxygen cost is much lower than $1.60 a hundred cubic feet. So we have our commodity at a very low figure.

But, gentlemen, we have a labor cost of somewhere over $1.25 an hour, and we have an overhead cost which is higher than that of the little fellow around the corner who pays $1.60 a hundred cubic feet for his oxygen. And unless you take the cost of your commodity, your labor, your overhead, and everything else in your mill, into consideration, there is no use saying, "I can cut cheaper with acetylene and you can cut cheaper with propane than somebody else with coke oven gas." I have run many tests on cutting where they could have received their fuel gas for nothing, and it would still cost them too much money to do their job than it would have cost with acetylene at the price they were paying for oxygen.

After your oxygen price goes down below a certain level, you can use any fuel gas that you can get and cut cheaper than you can cut with acetylene, even generated acetylene at $1.50 a hundred cubic feet out of your generator.

But that is not the whole story. You have to overcome the overhead and labor factor, and the only way you can do that is by increasing your speed. If you can increase your speed and produce 25 per cent more work in 60 minutes by one method, then you can use quite a lot of the cheap commodity that it takes to do that

work and so bring your price down to a lower level than somebody else doing it with some other method.

Did we try acetylene? Well, my first acquaintance with Lukens Steel was back in 1925, and they used acetylene to my knowledge up to about '36 or '37. Then they went to propane. Here we come to a cheap commodity again. Down at Sparrows Point you have coke ovens, you can charge nothing for your coke gas, if you want to, but let us say it costs you six cents a thousand. Lukens Steel Company some years ago was farsighted enough to see the advantage after they got their oxygen consumption up to a high enough figure to get in some other fuel gas, not mainly for flame cutting, but for use in their furnaces and in their boilers also. They knew there was a natural gas line that ran about 16 miles away from the plant and all they had to do was to get a line tapped into it. That was done. We get natural gas at a low figure, not on account of the amount used for cutting but on account of the open hearths and boilers that natural gas is used in.

So that builds up the story I am trying to tell you, if you can get your commodity cheaply enough, you can use any sort of fuel gas with your oxygen, providing your oxygen cost is down below a certain figure, because it does take more oxygen to burn the other gases than to burn acetylene. Any man who knows his chemistry or anybody at all who is versed in fuel gases knows that that is true regardless of what sort of selling arguments have been put forth for the use of acetylene.

Now, that does not necessarily settle the question because you would like to have me give concrete examples, and I honestly can not. All I can tell you is this. It is cheaper for the Lukens Steel Company to use natural gas for cutting and scarfing than any other fuel gas that can be used for that purpose. I will put it this way, if you have a problem in your plant, you have got to work it out according to your conditions.

Now let us go to the apparatus. The matter of tip design is something on which the apparatus companies have been striving for years. Tips have been made in many ways. We use a tip with a skirt on it. It has to have a skirt on it for natural gas. That is what we thought up until two weeks ago, when somebody came out with a new design, which does not have a skirt on it and it works.

Another question asked was about bobbing. Bobbing is a term — you take a tool about three-quarters of an inch to an inch square and put it in an air gun and hold the air gun vertically and it bounces up and down and cracks off the scale.

A. E. Cichelli: You said, I believe, "get your commodity cheap enough, then consider overhead." Please elaborate upon your discussion of speed in this connection.

Fred Judelsohn: I said that normal speeds in deseaming are from 30 to 50 fpm, depending on the material on which you are working. On the low carbon steels where you always turn up a flash, that has to be worked off. You have to hold your torch on an angle, sometimes 30 degrees to your line of travel so that each succeeding cut will wash off the fin that is left by the previous cut, and that slows down your speed.

On the higher carbon steels, where you do not get that condition, you can hold your torch almost parallel to the line of your cut and, of course, you can go at the higher speeds.

A. E. Cichelli: I mean comparative speed between acetylene and natural gas.

Fred Judelsohn: With the starting rod attachment, gentlemen, you can not time the difference.

Mr. Fitzpatrick wanted to know about single or multiple tips in the torches. They are single tips, just one tip in a torch, with a round 3/8 in. hole in it.

We do not do mechanical scarfing in our plant as in others where they have scarfing machines, some of which are in the production line as at Sparrows Point, where they do the whole four sides of an 8 by 8 in. bloom in one pass at a speed of anywhere from 90 to 110 fpm as it goes through the rolling line.

Mr. Horko wanted to know about spoilage, how much work does a new operator spoil. Well, first of all, we give him a poor piece of steel to start with. We are not going to give a green hand a powerful tool like a 3/8 inch hole tip in a scarfing torch, 4500 cubic feet of oxygen an hour and a good piece of steel to practice on. No. We start him out with a poor piece and as he gradually advances he gets the better work.

In a former job, I happened to be breaking in scarfers in Bethlehem and we were forced during the war years to try to use the work the green men were turning out, and the green women, for we had women scarfers up there, and it was not good. We did not gain very much because the good boys had to come in and clean it up afterwards.

So start in your green men on work that you can afford to play with and gradually advance them as they get better.

Mr. Deimler raised the question about what we do about the hard skin that we get. I can not answer that because we do not get a hard skin. Perhaps you can tell me what you mean or elaborate on that a little further.

J. W. Deimler: I understood in scarfing, due to the intense heat, you change the structure of your steel and get a type of case hardened steel on the surface, after making the cut.

Fred Judelsohn: If you were to take a piece of steel which was 30 carbon or over and scarf it cold, you would naturally get a hard case adjacent to your scarfed surface due to the intense quenching action of the body of the steel. That is why on any steel that shows a tendency to do that, it is usually pre-heated to about 400 F and then slowly cooled afterwards, or else put in re-heaters and brought up to the temperature to be put into the pits. Naturally if you try to scarf a steel which has a tendency to transverse check and you do it cold that is just what will happen, it will transverse check. Therefore you put enough heat into it to slow down that quenching action, and you do not get the checks. We do not have any trouble that way.

Mr. Moses was talking about flash and about shadow streaks. Flash is what you get, we call it either flash or fin, when you are scarfing low carbon steel, and I have described how you get away from that. It takes a skillful operator to do it. It is not the easiest thing in the world to do, but a skillful man gets rid of his flash as any of you men here know who are acquainted with scarfing or deseaming.

IMPROVED DESIGN FOR *Rail and Structural Mills*

. . . . this description of a combined rail and structural rolling mill built for a steel plant in Europe describes some of the latest developments in such equipment . . . .

By H. F. VOIGT
and F. EISEL
United Engineering and Foundry Company
Pittsburgh, Pennsylvania

▲ IMPROVEMENTS in rolling mill equipment resolve themselves principally into design details. As improvements in design details become highly technical and controversial, only the highlights will be emphasized in this paper.

Figure 1 shows a 46 in.-35 in.-32 in. blooming, rail and structural mill of our design and manufacture. The equipment was laid out to produce roughly 1,000,000 tons of finished and semi-finished products consisting of:

1. 300,000 tons of slabs — 4 to 11 in. thick × 24 to 48 in wide.
2. 300,000 tons of rails — 75 to 150 lb per yard.
3. 250,000 tons of beams and channels — standard beams up to 24 in.; H beams up to 8 in.; 3 degree taper wide flanged beams up to 21 × 8¼ in.
4. 150,000 tons of angles — up to 9 × 9 in., rounds, billets and blooms up to 14 in.

The ingot sizes to be used for making these slab products and for rolling the blooms and beam blanks for the rail and structural products vary from a 22 in. × 24 in. × 10,200 lb minimum ingot to a maximum ingot of 25 in. × 58 in. × 22,000 lb.

The roll pass design for the rolling of the slab, beam blank and bloom products and the subsequent rolling of same to final rail and structural products will be described later in this paper.

The first improvement in this layout is the space allowed.

The main mill building is approximately 100 ft wide and extends approximately 2700 ft. The soaking pit building housing the battery of soaking pits is off to the right another 500 ft. This layout is extremely flexible inasmuch as it includes several outlets for the same products. The major improvement in this layout, from our point of view, is the rail finishing end, which this paper will describe in detail later.

A brief description of this equipment layout is: a traveling tilting ingot buggy geared to operate at 400/800 fpm; an ingot receiving table; ingot scale and turntable for weighing and turning the ingot 180 degree; a 46 × 100 in. 2-high reversing blooming mill unit complete with front and back tables, individually driven feed rollers, double rack type manipulators with tilting fingers on entry side only, universal spindles and couplings, 46 in. pitch diameter pinion stand and motor-driven roll changing rig. Mill rolls are equipped with fabric bearings and top roll is counterweight balanced. There is a two-motor operated roller bearing equipped screwdown with mechanical and selsyn roll opening indicators. The mill has maximum roll opening of 56 in. and is driven by a 7000 hp 0/40/100 rpm reversing d-c motor with Ward Leonard control; mill runout table; shear approach table; No. 200 down and upcut shear, d-c motor driven, start and stop operation; shear pull-back table; shear gage; crop pusher and crop conveyor; shear delivery table; two slab pushers with pilers and overhead air stamping machines for slabs; two bloom pushers with bloom transfer, stampers and piling cradles. These machines constitute the 46 in. × 100 in. 2-high reversing blooming mill unit.

The 35-32 in. rail and structural mill unit comprises the following machines: transfer running tables; bloom pusher; bloom transfer; bloom feeder tables; furnace approach tables; two bloom skids and feeders; three furnace pushers; three reheating furnaces, 18 ft × 80 ft-0 in. long, with skids and bumpers; furnace delivery tables; 35 × 92 in. 2-high reversing breakdown unit, complete with front and back tables, individually driven feed rollers, double rack type manipulators with tilting fingers on both sides, universal spindles and couplings, 35 in. pitch diameter pinion stand and motor-

Presented before the AISE Buffalo District Section Meeting, February 11, 1947 and the AISE Chicago District Section Meeting, April 1, 1947

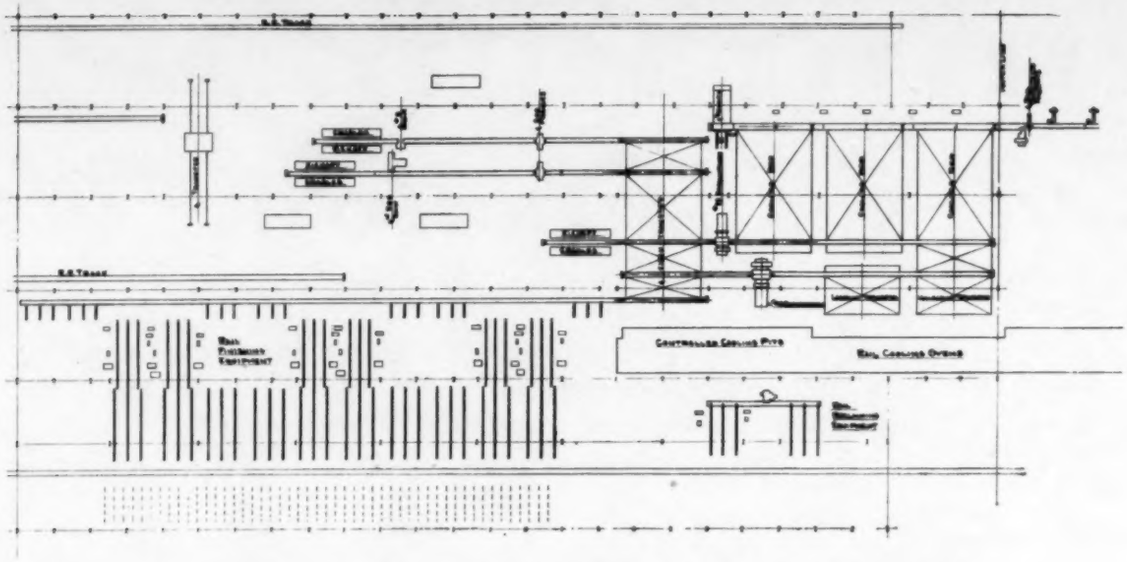


Figure 1 — This layout of a European mill consists of a 46 in. blooming mill,

driven roll changing rig. Mill rolls are equipped with fabric bearings and top roll is counterweight balanced. There is a two-motor operated roller bearing equipped screwdown with mechanical and selsyn roll opening indicator. Mill has maximum roll opening of 30 in. and is driven by a 5000 hp 0/50/100 rpm d-c motor with Ward Leonard control; roughing mill runout table; intermediate transfer runout table; two transfers; shear approach table, one No. 125 down and upcut shear, a-c motor driven with clutch for start and stop operation; crop buckets; shear, delivery table; shear gage; unload ing table; bloom pusher with transfer and piling cradles. The auxiliary equipment just described works in conjunction with the reversing breakdown mill when large rounds 8 to 14 in. diameter and blooms up to 12 in. are rolled on the 35 in. 2-high reversing roughing mill. The 32 in. 3-stand mill can be roll changing when these larger sections are being rolled.

The 3-stand 32 in. rail and structural mill equipment, which works in conjunction with the 35 in. reversing breakdown mill, has four stationary tilting tables with hydraulically operated manipulators and side guards. As these tables differ from the standard traveling tilting tables inasmuch as they are stationary and have manipulation embodied in the tables, it might be interesting to spend a little time on their detail.

There are five front and back mill tables, motor tilted, equipped with hydraulically and air operated side guards and roller type manipulators. The table at the entry side of the 2-high finishing mill does not tilt. No structural sections have to be manipulated, but usually the second and third passes, when rolling rails, have to be turned 90 degrees. However, on account of customer's requirements of rounds and squares from 4 to 8 in. to be delivered off this 3-stand rail and structural mill with no hand turning allowed, it necessitates the design of a stationary table with manipulator for manipulating the ovals and diamonds for making the final section of squares and rounds.

Both air and hydraulic cylinders are utilized for actuating the side guards while hydraulic is utilized for lifting roller No. 2 of the roller type manipulator.

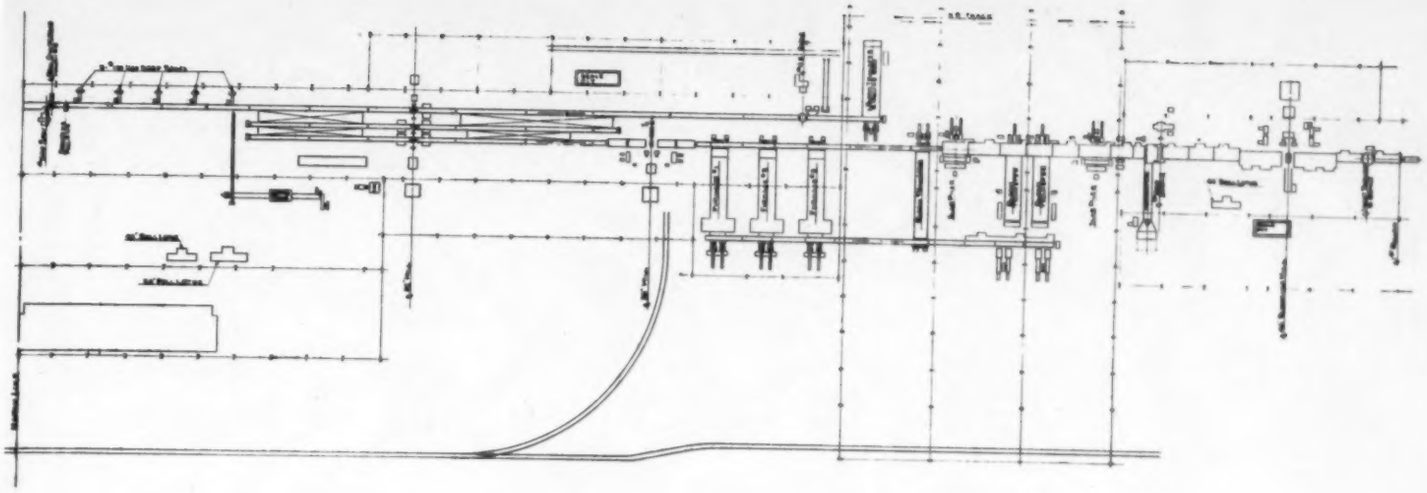
Each manipulator consists of a pair of vertical grooved rolls with each roll frame mounted on bronze slides so rolls can be moved horizontally across the table. Roll No. 1 is motor driven through a worm gear unit and a free wheeling clutch. This permits the piece being rolled to be brought up to the mill with the vertical rolls, and as the mill rolls pick up the piece for rolling, the speed of the mill may be faster than the vertical rolls and then the clutch allows the driven vertical roll to be pulled ahead of its motor and drive. The horizontal movement of this roll is by the hydraulic cylinder "A" operating through bell crank and links below the table. The roll and its drive and motor move as a unit, all being mounted on the sliding frame.

The other roll No. 2 is not driven. This is the manipulating roll used for turning the piece being rolled and for holding the piece in the proper position while rolling. It is raised and lowered with a hydraulic cylinder "D" controlled through a valve — which is selsyn motor operated.

The horizontal movement of this roll No. 2 is by an air cylinder "B" operating through bell cranks and links below the table. Both rolls can be moved together as a unit. Side guards have been provided both front and back of the vertical manipulating rolls.

The general operation is as follows: The blooms and billets are delivered from the 35 in. mill on to the first front mill table. At this point two procedures may be followed: first, the side guards and manipulator rolls may be preset to be in line with the first pass through the mill, and no manipulation of the piece is required. Second, the side guards may be opened and the piece comes on to the front table and table is stopped. Side guards and manipulator rolls are brought together on the piece using the two air cylinders "B" and "C." Then the piece is moved horizontally across table rollers to the proper roll pass, using hydraulic cylinder "A," the air pressure remaining on the air cylinders. At times it may only be necessary to move the one side guard with the hydraulic cylinder "A" depending on what roll pass is being used and also on to which side of the table the piece is delivered.

After the piece has passed through the mill, the manipulator and side guards on the delivery table are



and a 32 in. and 35 in. rail and structural mill.

brought together on the piece using the two air cylinders on this table. Then the piece is moved horizontally across the table rollers to the next pass back through the mill rolls.

The one side guard between the mill and the vertical manipulator roll having an independent movement, can be made bell-mouthed by operating its air cylinder "C" alone, thus providing clearance as the piece comes through the mill.

As mentioned before, when rolling angles, channels and beams, no manipulation of these sections is required other than moving pieces from one roll pass to another. In the case of the sections that have to be manipulated and turned, for example: a rail to be finished, then the bloom partially shaped in the 35 in. mill is delivered to the first entry table with that portion that is to be the rail flange riding the table rollers. The table is stopped and the idler grooved vertical roll brought in on the piece, using the air cylinder "B." The idler vertical roll is then lifted hydraulically. The "V" groove of this roll raises the piece and in so doing, the piece rides into the groove of the driven vertical roll which frees the piece and allows it to turn. The idler roll is then lowered, permitting the piece to return to the table rollers turned at 90 degrees, after which it goes to the mill with the vertical rolls acting as guides for keeping the piece in the proper position to enter the mill rolls, because on some of the passes, the side of the piece is not flat as it rides on the top of the table rollers.

As the piece is delivered from the mill on the back table and no manipulation is required, the vertical rolls with side guards are then moved across the table taking the piece with them until they are positioned in front of the next pass in the mill rolls. In other words, the vertical rolls and side guards merely are used as a means of holding the piece in the same plane coming from one pass and entering the next pass.

The six front and back tables can be moved hydraulically away from mill housings, thus permitting ease of roll changing mill stands and permitting first table rollers at entry and delivery side of mill to be as close as possible.

The 3-stand rail and structural mill consists of 32 × 76 in. 3-high rougher and intermediate mills, while the finishing mill is a 32 × 48 in. 2-high. All stands are of the standard type with fabric bearings and hand ratchet type worm screwdowns. A complete set of spare stands are used for ease in roll changing. Also the 32 × 48 in. 2-high finisher is interchangeable with a 36 in. 2-high universal beam mill having a 31 in. diameter idle vertical rolls which can be used for making the 3 degree tapered wide flanged beams and large standard beams. The 3-stand mill train is driven from the roughing side by a 6000 hp 0/70/140 rpm d-c motor and from the finishing side by a 2500 hp 0/70/140 rpm d-c motor.

Referring to the hot finishing end behind the 3-stand structural mill, the following machines constitute same: one saw table with scale for rails; five drop saws for rails, and one No. 300 sliding frame hot saw with clamps and gage for squares, rounds and structural shapes (the drop saws have blades of 48 in. diameter and a peripheral speed of 21,000 fpm, while the sliding saw has a 60 in. diameter blade with a peripheral speed of 19,000 fpm); one rotary stamping machine; one rail cambering machine; one bloom pusher, and one bloom transfer with cradle for large size blooms that have been sawed and are needed at some other source rather than go over the cooling beds; three cooling beds with tables. The total capacity of the cooling beds is about 30,000 square feet. Each bed is split into two sections which are individually driven but can be coupled together and operated as a unit. The usual turn-up devices for beams and channels and ducking dogs are embodied in the cooling beds. There is one unloading transfer for unloading the rails from the cooling beds to the slow cooling pits, these cooling pits are of concrete, brick and steel design and are located beneath the floor; and there is one No. 45 roller straightener for rails and large structural sections; one No. 32 roller straightener for small structural sections; and one loading transfer for the rails after same have been cooled in the pits and are now to be returned to the No. 45 straightener for straightening and subsequent finishing at the rail finishing end.

In the case of structural sections and rounds and squares, the flow of the material after being discharged

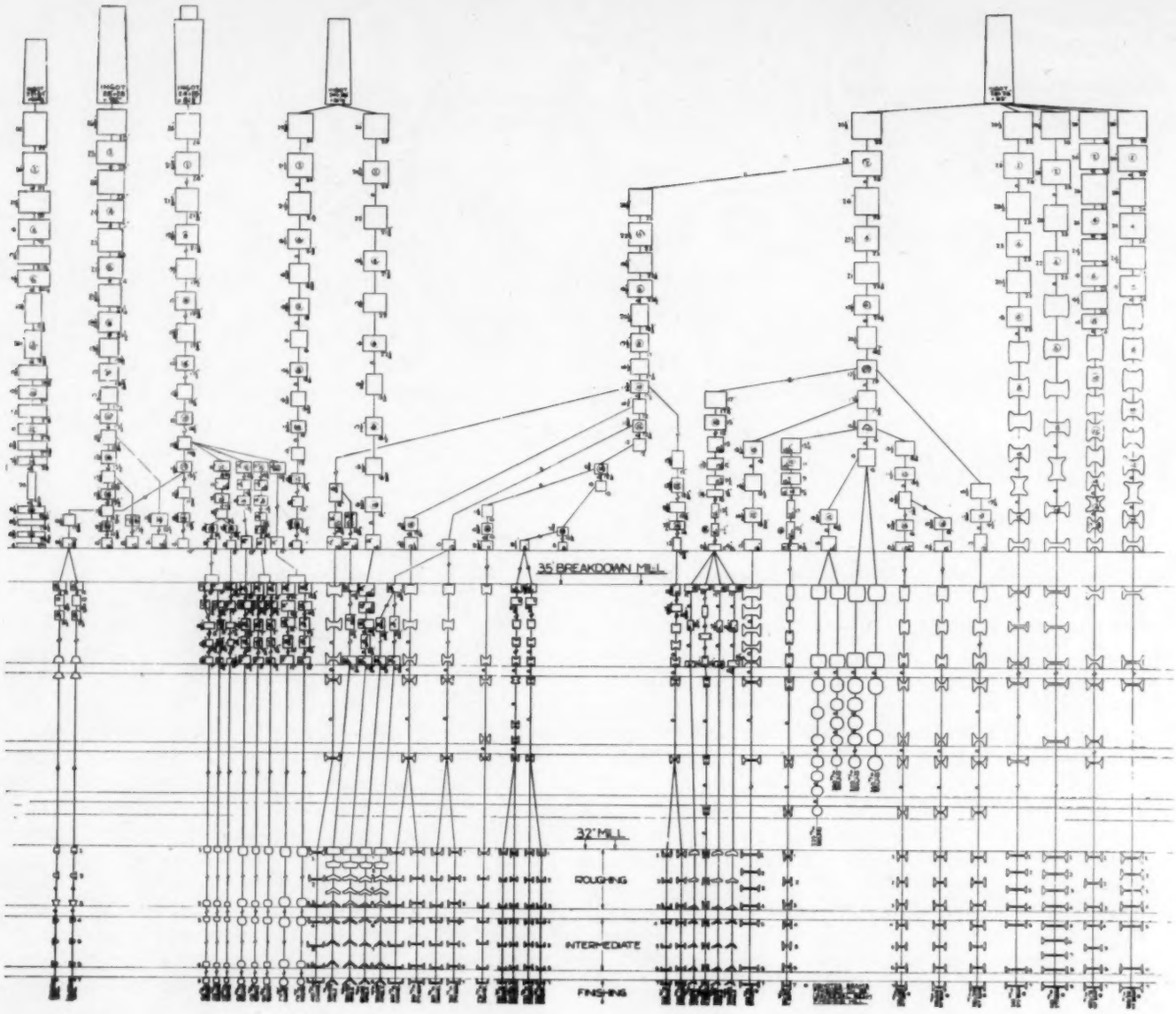


Figure 2 — This layout shows the development of the various finished products from the ingot.

from the cooling beds on to the runout table is as follows:

In the event of structural sections or angles up to 9 × 9 in. channels and beams up to 14 in., the flow of this material will be through the No. 32 straightener across the chain transfer to either the vertical shear line or the sliding frame cold saw line. Both the shear line and the saw line have horizontal gag presses for additional straightening. In the case of large structural sections of beams up to 24 in. and channels up to 16 in. including angles 9 × 9 in., these structural sections are transferred from the cooling bed runout table at No. 1 cooling bed to the No. 45 straightener, and the straightened sections then follow the same line of flow as the lighter structural sections delivering from the No. 32 roller straightener.

After the rails have pit cooled, they are returned to the loading transfer by magnet lift, then through the No. 45 straightener for straightening, across the chain transfer to the rail delivery table. This rail delivery table is approximately 642 ft long, and each table roller is individually motor driven. This table conveys the rails to any one of the six rail finishing bed units.

Before describing the details of this rail finishing end, we should point out that each rail finishing bed is capable of processing one finished rail per minute. In other words, it is faster than the average rolling rate of about one rail bar per minute of the mill. However, the rate of processing a rail at one of these beds is dictated by the straightening method used.

In our country it is common to gag straighten rails only, rather than roller straighten them or to use a combination of both roller straightening and gag straightening. In European countries the common method is one of roller straightening using the vertical gag straightener only as a method of straightening the front and tail ends of the rails. This layout permits either method, but the layout is predicated on roller straightening first, and then spending a minimum time at the gag straightener to obtain a commercial straightened rail. Thus, the one minute cycle we expect to obtain on a finished rail which has been roller straightened,

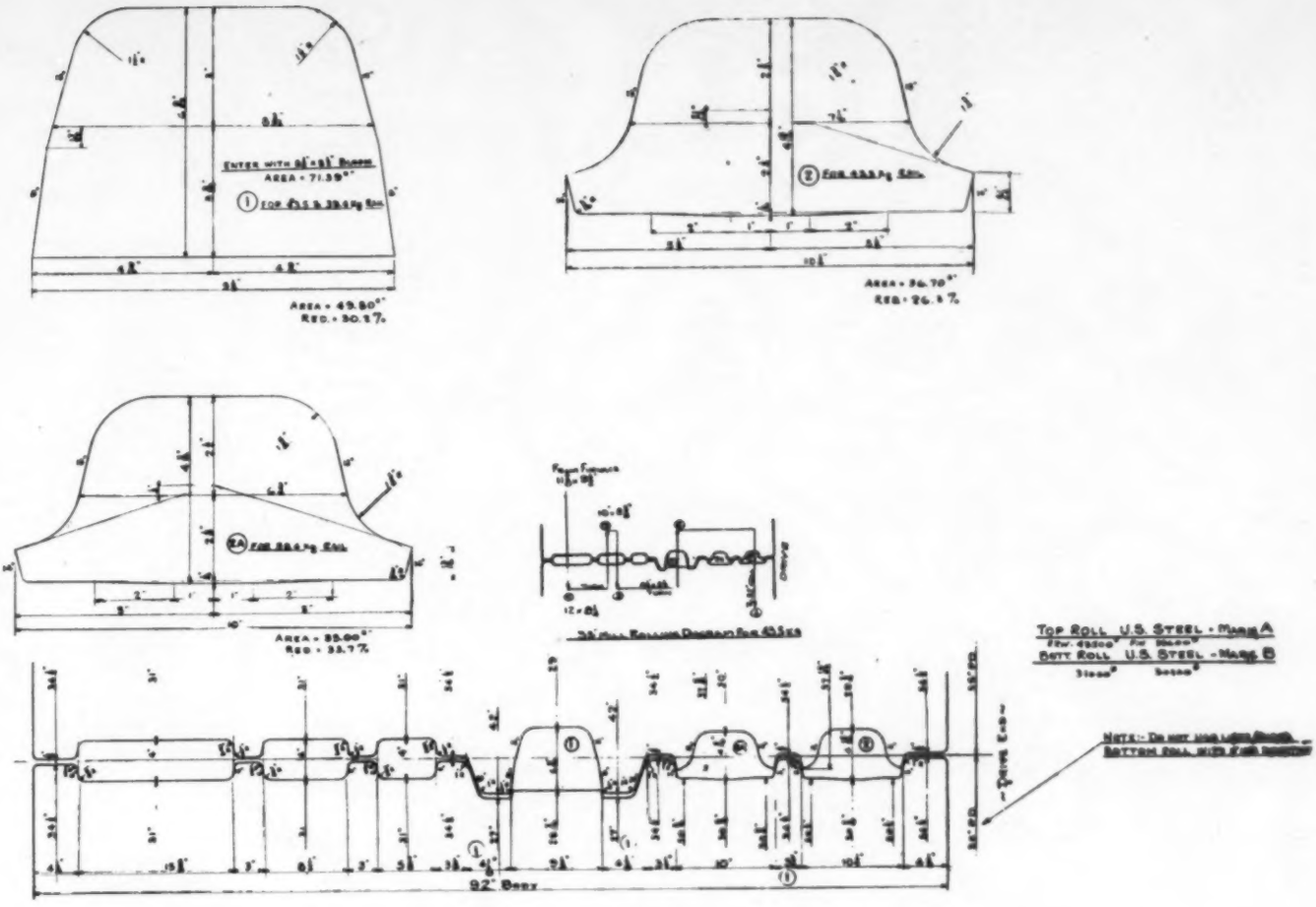


Figure 3 — Shown here is the 35 in. mill breakdown for the 43.5 and 38.4 kilogram per meter rail sections.

gag straightened, end milled, drilled and end hardened permits, therefore, no longer than a minute in the gag straightener. This cycle compares with the average cycle in our country of utilizing about 8 to 12 blows at the vertical gag straightener equivalent to about 1½ to 2 minutes per rail which results in a rate of about 30 to 40 rails per hour as against the 60 rails per hour of this layout.

In any event, as a result of extensive study by our engineers of various rail mills, the consensus was to keep manual operations of sliding and turning the rails to a minimum. Each of these lines is semi-automatic and it is only necessary to turn rail once, after the drilling operation and prior to the end hardening operation. This single turning might also be eliminated if the drilling machine was of the horizontal type.

The complete cycle of one minute for finishing the rail is broken down about as follows, keeping in mind that all operations once the bed is filled up happen simultaneously: milling faces of rail — 50 seconds; drilling ends of rail — 45 seconds; end hardening of rail — 52 seconds.

At each of the six machines in this production line, a push button is located for actuating main shuffle bed after each operator has performed his operation. However, not until all six buttons have been pushed, assuring that milling, drilling and hardening operations are finished, will the shuffle bed operate.

The equipment of the rail finishing beds is laid out to satisfy a single length rail up to 41 ft or a double length rail of about 82 ft by relocating the machine tools.

This layout includes six 24 ft long × 25 ft wide reciprocating type beds which shuffle the rails from the rail delivery table to the entry side of the vertical gag press. The six main beds are each 70 ft long × 25 ft wide, which shuffle the rails from the delivery side of the gag straightener through the milling, drilling, and end hardening operations. The six stacking chain conveyors stack the rails in bunches of ten or less for lifting same by magnet to inspection and storage, or after these rails have been stacked, they can be further moved directly into the inspection building by means of the lifting chain conveyors.

The operation and description of one of these rail finishing lines is as follows: a disappearing stop is located in the rail delivery table to correctly stop the rail which has been roller straightened for transferring on to the shuffle bed at the entry side of the gag straightener. The rails are pushed off the rail delivery table on to this bed by means of a hydraulic operated carriage equipped with tilting dog, which is built into the aprons of the table. Each bed consists of three skid rails and two shuffle bars with multiple tilting dogs spaced on 11 in. centers and are reciprocated by means of a crank and worm drive from a mill type motor. The shuffle bars equipped with the tilting dogs are supported by stands equipped with idler rollers. The crank drive

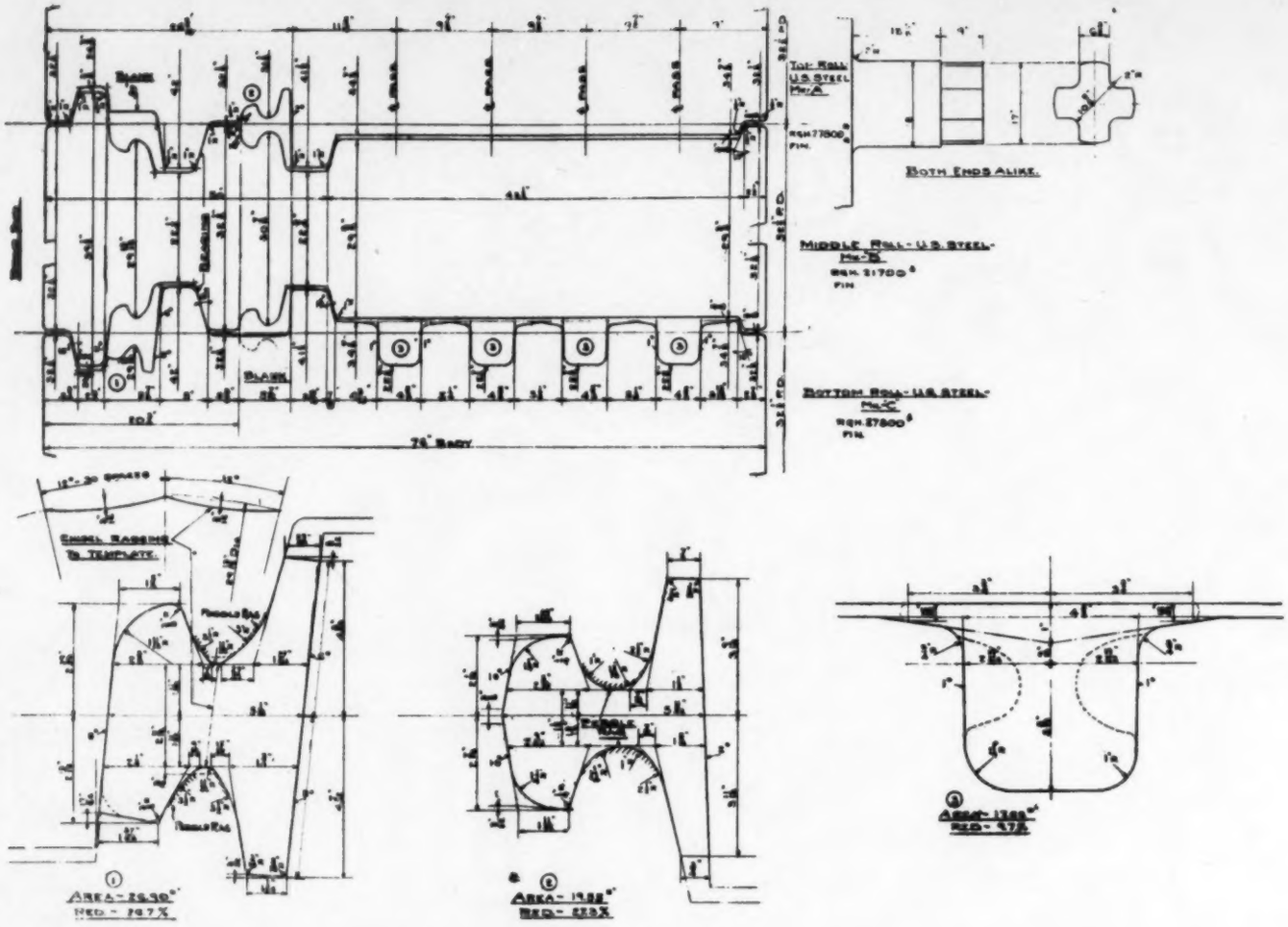


Figure 4 — The 32 in. mill roughing rolls are 32½ x 76 in.

operates at about 9 strokes per minute and each stroke advances the rail approximately 12 in. Each bed serves as storage bed and at the same time permits preliminary inspection and chippers to chip any burrs from the ends of the rails. Each of these beds function alike and as each rail is pushed on to the skids, the shuffle bars are moved one dog space until the bed is filled up with one rail at each dog. This is the normal single cycle operation, but operator can operate the shuffle bars continuously so a single rail may be moved over the entire bed at one time if occasion should demand.

The final stroke of the shuffle bed is such as to deposit a rail on to the table at the entry side of the gag straightener, which table is equipped with both idler and motor-driven rollers, the rail is then fed to the gag straightener which is of the vertical type. A rail turner of the motor-driven type for manipulating rail is located on the delivery side of the straightener.

After the rail is straightened in the gag press and delivered out of same, the rail approaches a stationary stop in the delivery table so located as to position rail in the exact position for transferring across the main bed. Operator of the rail turner turns rail just before it leaves the rail turning machine so that rail is on its side with flange facing toward main shuffle bed so rails can proceed across bed with flange leading. The rail is then transferred by hydraulically operated dogs from the gag press delivery table on to the main shuffle bed. Each main bed is similar in design to the short shuffle bed with two shuffle bars riding on idler rollers, and each with multiple tilting dogs, crank driven for cycle operation from a mill type motor. The dogs are spaced on 18 in. centers, and the crank drive operates at about seven strokes per minute, and each stroke advances the rail approximately 20 in.

For best operation on each of the main shuffle beds, they should always be full of rails, that is, one rail every dog space so that all operations can happen simultaneously.

Each rail can be gaged for length as soon as it comes on into the shuffle bed to observe how much is to be milled off for standard length with tolerance. The bed stroke is such that the first rail is deposited exactly above the collared rollers leading into the first milling machine. The operator then raises the two collared rollers which are actuated by a hydraulic cylinder and are motor driven. These collared rollers raise rail off the skids and the rail is then lead into the first milling machine.

Each milling machine has a motor-driven horizontal spindle on which is mounted a 20 in. diameter head with three inserted cutting blades. The spindle operates at a speed of 4 to 8 rpm. The traverse feed of the spindle is hydraulically operated at a feed speed of 0 to ½ in. per minute and a rapid traverse speed of 0 to 30 in. per minute. Each machine is equipped with a hydraulically operated hold-down clamp and a hand operated side clamp. A graduated scale and pointer have been pro-

vided to preset the length of the cutting stroke. An automatic cut out feature is built into the main operating valve.

After rail is entered into the clamps and strikes the stop, the stop is released and the rail is clamped horizontally between the rigid head on one side and the screw adjusted head on the other side. Then the overhead hydraulic main clamp comes down on the web, locking rail rigid to anvil block.

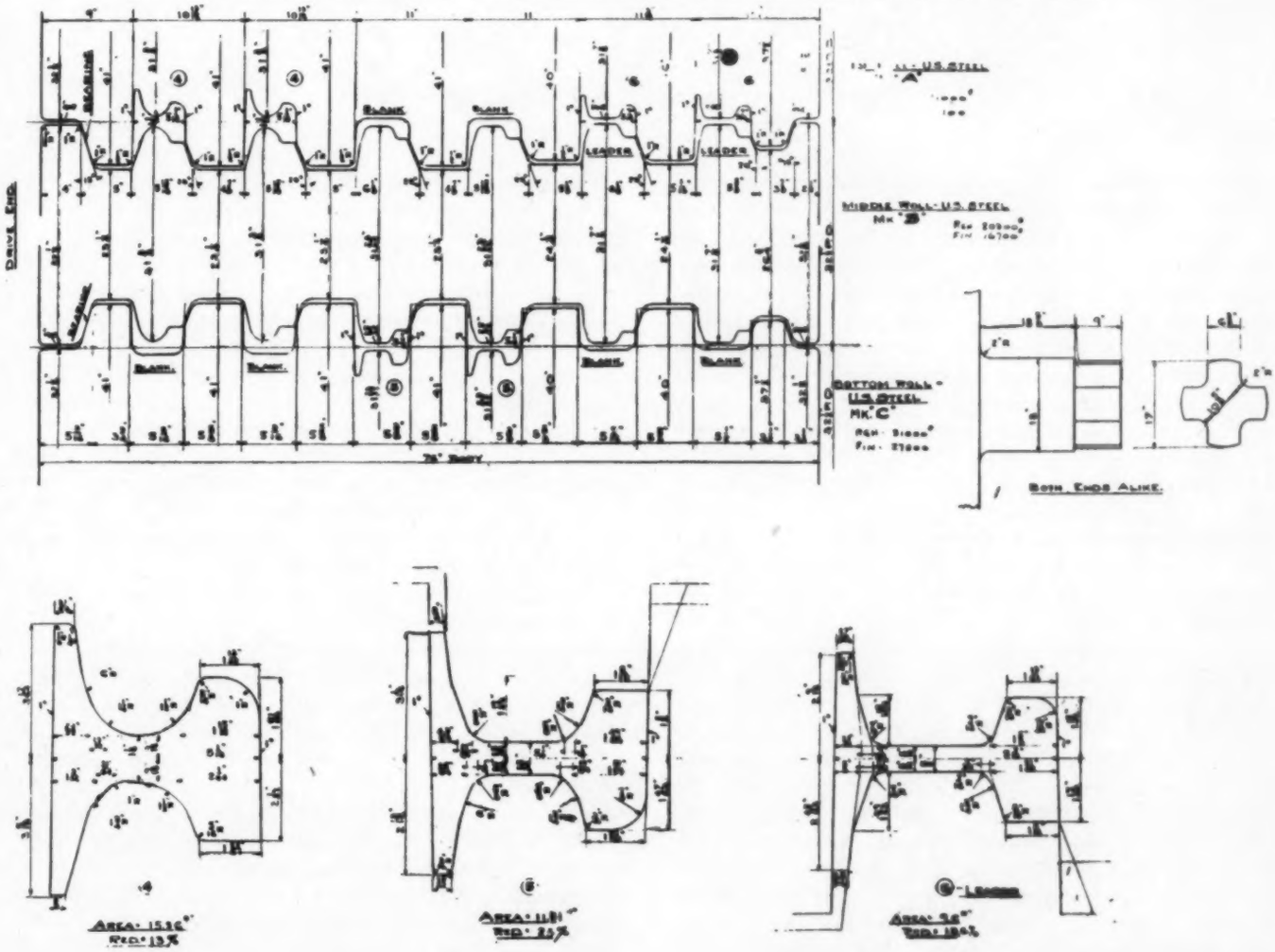
Main operating valve is then opened manually, thus starting the horizontal traverse feed at a fast rate. As the cutter head approaches rail, the manually operated valve handle is released and the valve resets itself to the preset slower cutting speed. Stops on the rod on valve come into play as cut is finished and the feed stroke is stopped. The operating valve handle is then moved to neutral and then to reverse, returning cutter head to the starting point at a rapid traverse speed.

After milling the correct amount off the face of the rail, which can be set automatically, clamps are released and rail is run back out of the machine on the collared rollers to a rigid stop on the far side of the bed. The rollers are then lowered, placing rail again on skids. The milling machine operator then pushes his push button for starting up shuffle bed. This bed as mentioned before will not move until the "all clear" buttons are pushed at the other machines, signaling that operations are finished. The rail is then progressively advanced until it reaches the next milling machine where the opposite end of this rail is milled in the same manner.

The rails are progressively advanced up to and into the drilling machines in the same manner as to the milling machines. Each drilling machine is a three spindle type vertical drilling machine with horizontal feed for making circular and oblong holes. Both the vertical and horizontal feed are hydraulically operated from an oil gear pump through cylinders. The three spindles operate at a speed of 45/180 rpm and are motor driven through gearing. The vertical and horizontal feed rate is 0 to 10 in. per minute.

The center spindle is stationary, while the two outside spindles may be adjusted horizontally for hole spacing. The maximum distance between any two spindles is 12 in. while the minimum is 4 in. This adjustment is accomplished by right and left hand screws, hand adjusted. The side clamps are also hand adjusted. Each machine had capacity to drill three holes simultaneously up to 3 in. diameter. A coolant system is included with each machine for the drills. The machine

Figure 5 — Three passes are taken in the 32 in. intermediate mill when rolling the rail sections.



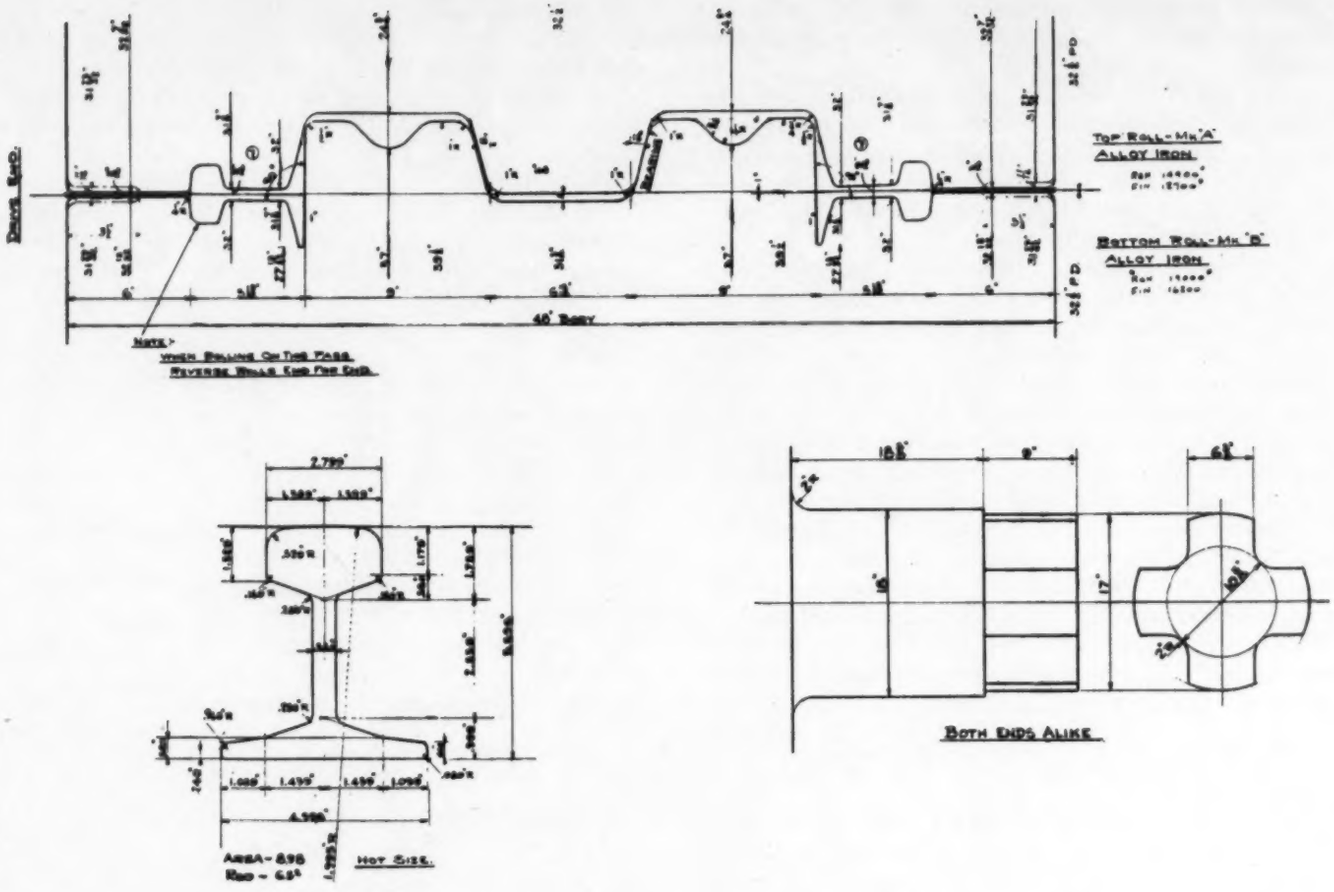


Figure 6 — One pass only is taken in the finisher.

is controlled by hand lever valve with automatic feature for drilling and milling.

Assuming the rail is now up against the adjustable stop at the drilling machine, rail is then clamped between fixed head and screw adjusted head. With spindles operating at desired speed, the main operating lever is pushed back to "start position," releasing the hydraulic pressure to the vertical feed. The drills come down rapidly to a predetermined position when a limit switch cuts in and slows down the feed speed to the preset cutting speed. After the web of the rail is drilled, the horizontal feed starts up automatically to mill oblong holes. Upon completion of horizontal stroke, the head automatically reverses to start position and stops. Then the vertical rapid lift raises the spindles to "up position" automatically, and operating lever is returned to neutral.

Clamps are released, rail runs out on collared rollers to fixed stop, rollers are then lowered, depositing rail on to skids. The drilling machine operator then pushes his "all clear" button, signaling that his operation is completed. The rail is then progressively advanced until it reaches the next drilling machine where the opposite end of this rail is drilled in the same manner.

Rail after leaving this second drilling machine is upset from the collared rollers so that rail is now resting on skids with flange down. Rail is then advanced to the two end hardening machines which are located opposite one another rather than diagonally like the millers and drillers. This arrangement permits both rail ends to be end hardened simultaneously.

Each rail end hardening machine is a duplicate of the ones now at a rail mill in the Braddock district, except that the motor generator sets are of the larger capacity, namely 30 kw, to satisfy the end hardening of rails in one minute maximum. In our particular case, the test run was a maximum of fifty seconds. The hardening apparatus consists of specially developed equipment including an induction heater, a quencher, control equipment, and a motor generator set to supply electric energy to the induction heater. Dual control cabins, each housing a heater, quencher and control equipment, are placed opposite one another so that rail hardening is accomplished simultaneously.

As the rail is progressed into the cabin, then stopped, an induction transformer in the form of an inverted "U" is placed on each rail end; the operator presses a remote control button which starts the heating cycle, current being supplied by 500 cycle alternators. Energy for the heater passes through watt hour meters in the control cabins and when the pre-determined quantity of energy has been delivered to the rail end, the watt hour meter rings a bell. The operator then removes the heater and places it on the next incoming rail and then places the quencher on the rail just heated.

Quenching is complete in twenty-five to thirty seconds, the time being determined by the hardness desired. Quenching is done by soluble oil kept at a uniform

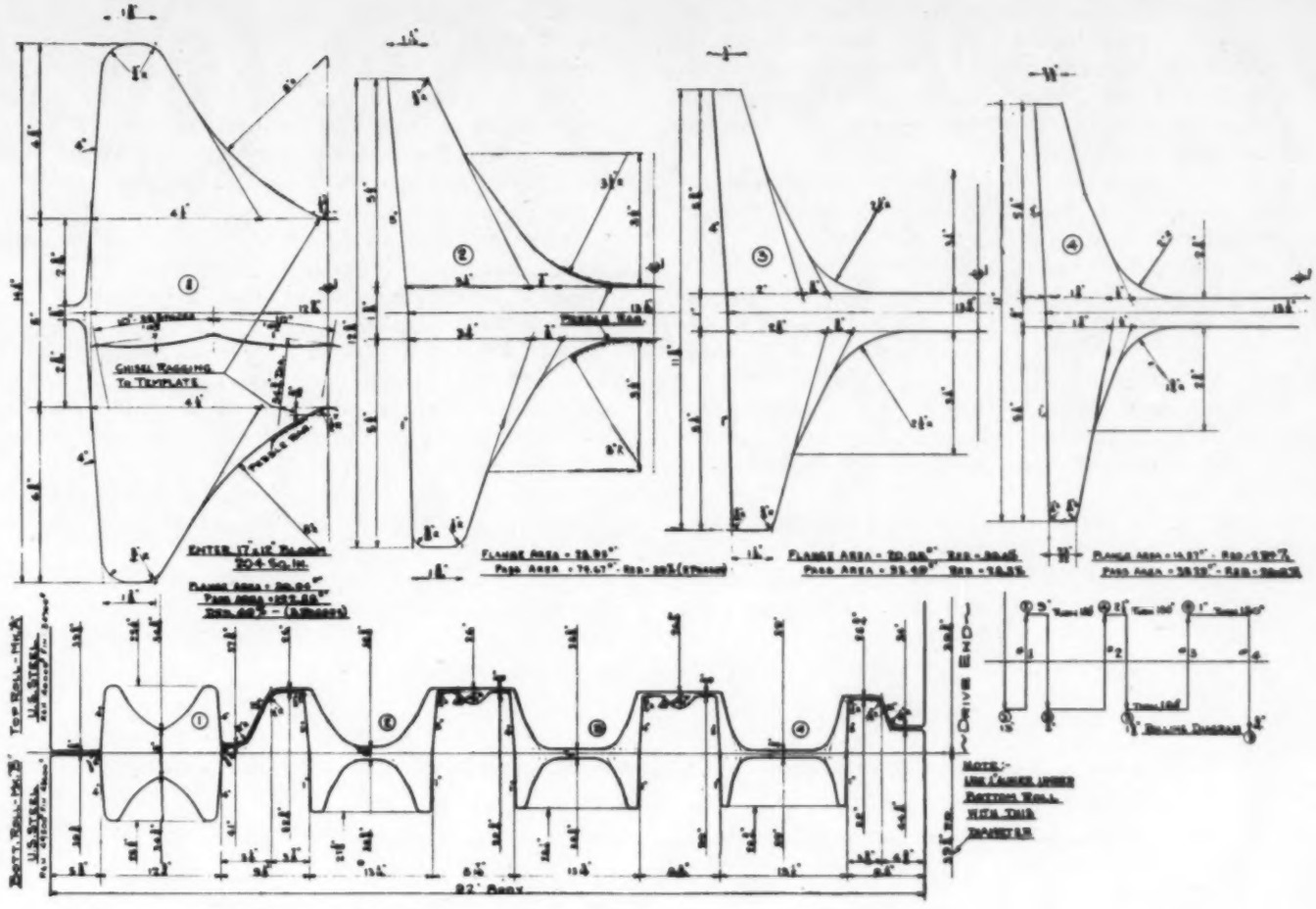


Figure 7 — This diagram shows the breakdown of the 17 x 12 in. bloom to the 14 x 8 in. wide flange beam

temperature. An evenly distributed stream of quench liquid flowing at considerable velocity toward the rail end is moved by a motor-driven cam actuating a nozzle which distributes the liquid at a pre-determined speed from the rail end to the rear of the heated area, when it is immediately returned to a position of rest near the rail end where it remains for a definite period. The quenching cycle is stopped automatically on the expiration of the present time.

The pattern of hardness which was recommended approximated a total length of about 3 in. measuring from the face of the rail and extending 3 in. from that point; the brinell hardness of about 400 at the rail end gradually decreasing to rail hardness of about 265 brinell. Maximum penetration of hardening was about ½ in. at rail end.

The general hardness level is controlled by the total time of quench and the graduation of hardness from rail end to the rear of heated zone by the rate of travel. Any desired hardness or hardness distribution may be produced. Then edges of the rail ball are heated to hardening temperature. Quenching practice may be adjusted to harden these edges to any desired degree, or they may be left at rolled hardness.

After rail has been end hardened, it is then progressed by the shuffle bed until reaching the stacking chain conveyor. Here the rail rests on the skids but is deposited over a two-strand section of stacking chains. The chains have two tilting dogs equally spaced, only one of which is used at a time. The top of chains is below the top of skids and as one rail comes on to the chain section, it is swept along the skids to the tail end of the bed. Chain then returns to starting point and takes second rail across and continues to do this cycle until a stack of ten or less rails are together. Then overhead crane with magnet removes stack from bed for final inspection or storage.

This layout also includes the usual reclaiming equipment for reprocessing the rejected rails, drop and break testing equipment and laboratory equipment.

ROLL DESIGN

The subject of roll design as applied to the great variety of shapes which this mill is capable of rolling is quite a lengthy one and therefore space will not permit a full description of each pass layout in detail. However, a general outline showing the development of sections rolled from ingots to finished product may be obtained from the chart as illustrated in Figure 2.

In order to familiarize you with the schedule of operations on these mills, a brief description of the sections illustrated will be explained; while later in this paper a detailed pass layout for the rail and wide flange beam will be described.

The small scale shape of grooves on this chart together

with their respective pass numbers and positions in the various roll stands are reproduced exactly as per the original roll design drawings. All the sections shown are European or metric standard sizes, and throughout the progress of this discussion their approximate American equivalent will be given.

46 *in. blooming mill* — Slabs, blooms and beam blanks are rolled by the usual method with which you are familiar and need no further description.

Five sets of blooming mill rolls 44 in. diameter × 100 in. body were designed and distributed in the following manner:

1. One set with 16 in. — 12 in. — 8 in. — 5 in. passes — 45⅞ in. bullhead.
2. One set with 14 in. — 10 in. — 8 in. — 5 in. passes — 48⅞ in. bullhead.
3. One set for 500 mm = 19.68 in. — European stand, beam blank.
4. One set for 600 mm = 23.62 in. — European stand, beam blank.
5. One set for 400 × 175 mm = 15.78 × 6.88 in. and 530 × 210 mm = 20.86 × 8.26 in. wide flange beam blank.

35 — 32 *in. mills* — Leaving the 46 in. blooming mill, blooms or blanks are cropped and sheared to the required length, charged into the reheating furnace, then further reduced in the 35 × 92 in. breakdown mill, passing from there through the 32 in. 3-stand mill to the required sections. The flexibility of the mill layout as previously described also permits direct rolling from ingot to finished product on the heavier shapes.

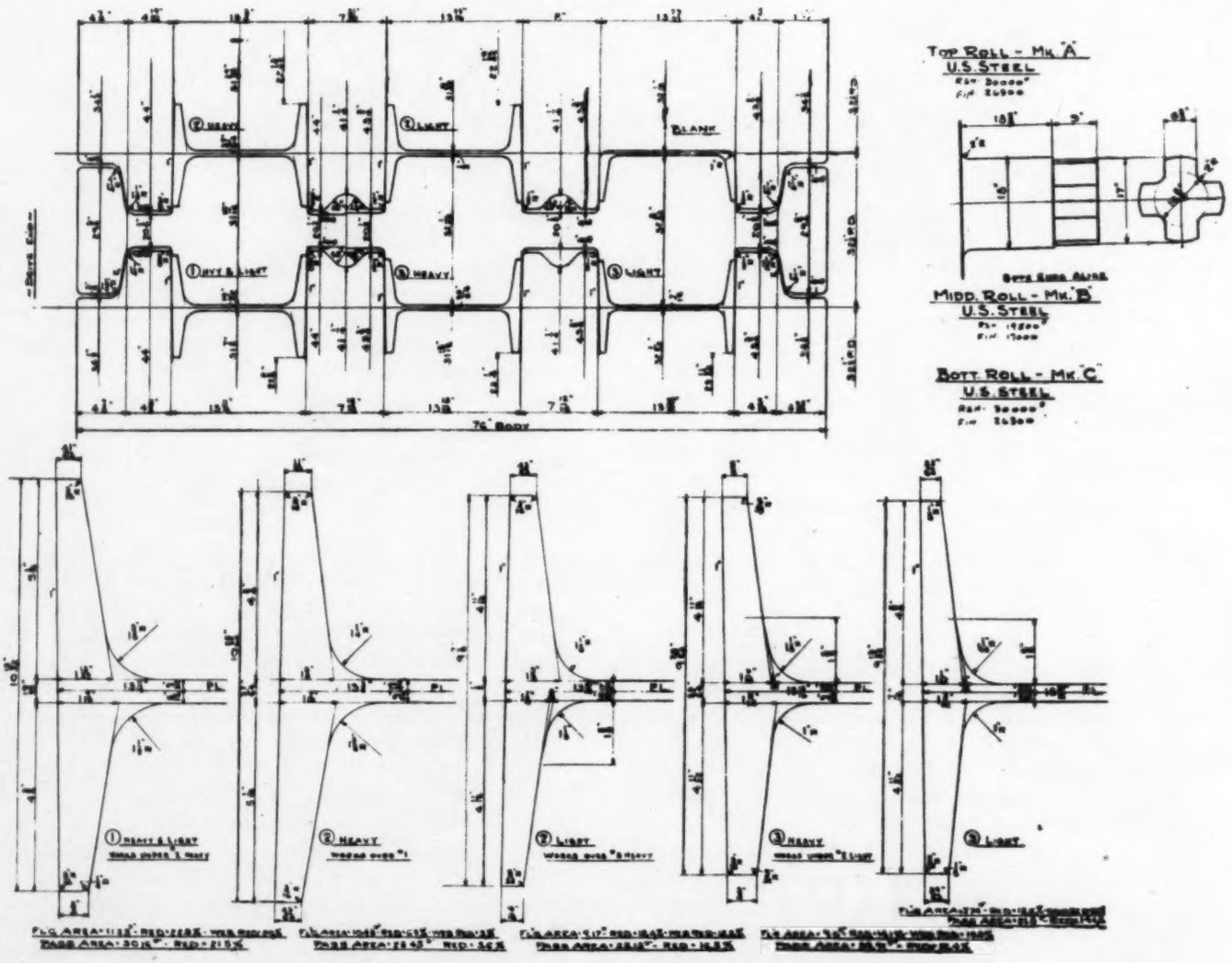
Outlining the sequence of operations on these two mills, we will start at the left of Figure 2 and describe briefly the sections in the order illustrated:

1. Rails — to be described in detail later.
2. Rounds and squares.

Blooms 8 × 8, 9 × 8, 10 × 8, 10 × 12 and 12 × 12 in. are broken down in five passes on the 35 in. mill to the required rectangular shape, then further reduced to finished round or square on the 32 in. mill by the following method.

Rounds.....	125 — 150 — 170 — 200 millimeters. 4.92 in. — 5.90 in. — 6.69 in. — 7.87 in. American.
Roughing...	No. 1 bottom — Box pass square with large corner radii. No. 2 top — Box pass flat with large corner radii.

Figure 8 — Not more than three passes at a time are used although there are five passes in the set.



Intermediate { No. 3 bottom — Octagon former.
No. 4 top — Octagon leader.
Finishing . . . . No. 5 bottom — Finished round.
Squares . . . . . { 110 — 125 — 130 — 150 millimeters.
4.33 in. — 4.92 in. — 5.12 in. — 5.90 in. American.
Roughing . . . { No. 1 bottom — Box pass square with small corner radii.
No. 2 top — Box pass flat with small corner radii.
Intermediate { No. 3 bottom — Box pass fluted sharp corner square.
No. 4 top — Box pass fluted leader.
Finishing . . . . No. 5 bottom — Finished square — Box pass.

The box type design for the squares was chosen to facilitate initial operations. Table manipulators are so designed to also accommodate the diamond pass method, and permits turning the bar 90 degrees after each pass, thus insuring quality product.

From the preceeding, it will be noted that grooves for both rounds and squares are arranged in the three high stands to permit only a single pass through top or bottom position, thus providing extreme flexibility for individual adjustment.

The complete range of rounds listed are incorporated in one line-up of eight rolls and those for the squares in a similar set.

Also illustrated in Figure 2 are four larger sizes of rounds:

225 — 250 — 300 — 350 millimeters.

8.858 in. — 9.84 in. — 11.81 in. — 13.77 in. American.

These are finished on the 35 in. 2-high reversing mill from 16 to 14 in. blooms and require the use of the top roll screwdown on both the box pass former and octagon leader preparatory to entering the finishing pass. The setting of the top roll with respect to the finishing pass and the final pass through the octagon leader must be predetermined by adjusting the screwdown indicator at the proper position on the dial to produce the desired size round.

Reasonably accurate rounds in the larger range of sizes can be made by this method.

3. 400 mm channel — Flange and web equivalent to 18 in. American standard.
400 × 100 mm = 15.748 × 3.937 × 0.413 in.
400 × 102 mm = 15.748 × 4.015 × 0.492 in.
400 × 104 mm = 15.748 × 4.094 × 0.571 in.
Bloom size — 14 × 12 in.
35 in. Mill — 5 passes: 3 — 1 — 1 } total 12 passes.
32 in. Mill — 7 passes: 3 — 3 — 1 }

4. Large equal angles { 180 mm — 200 mm — 220 mm 230 mm.
7.08 in. — 7.87 in. — 8.66 in. — 9.05 in. American standard.

Rolled from 10 × 12, 10 × 14 and 14 × 14 in. blooms, broken down to the required slab size in three or five passes on the 35 in. mill, then taking nine shaping passes on the 32 in. mill: 5 — 3 — 1.

Unequal angles { 200 × 150 mm — 200 × 120 mm 180 × 120 mm.
7.87 × 5.90 in. — 7.87 × 4.72 in. 7.08 × 4.72 in. American standard.

11¾ × 6⅛ in. slab — 3 pass on the 35 in. mill.

7 shaping passes on the 32 in. mill: 3 — 3 — 1.

5. 360 mm beam
360 × 136 mm = 14.173 × 5.35 × 0.393 in.
360 × 138 mm = 14.173 in. × 5.44 × 0.472 in.
360 × 140 mm = 14.173 × 5.51 × 0.551 in.
360 mm channel
360 × 96 mm = 14.173 × 3.78 × 0.354 in.
360 × 98 mm = 14.173 × 3.88 × 0.433 in.
360 × 100 mm = 14.173 × 3.94 × 0.511 in.

These shapes are approximately equivalent to our standard 15 in., with respect to flange width and web thickness.

Bloom size — 12¼ × 12¼ in.

35 in. Mill — 5 passes: 3 — 1 — 1 } Total 12 passes. Same shape from 35 in. mill for beam and channel.
32 in. Mill — 7 passes: 3 — 3 — 1 }

6. 300 mm beam
300 × 126 mm = 11.81 × 4.96 × 0.354 in.
300 × 128 mm = 11.81 × 5.04 × 0.433 in.
300 × 130 mm = 11.81 × 5.12 × 0.511 in.
300 mm channel
300 × 85 mm = 11.81 × 3.34 × 0.295 in.
300 × 87 mm = 11.81 × 3.42 × 0.374 in.
300 × 89 mm = 11.81 × 3.50 × 0.452 in.
Approximate equivalent American 12 in. — Bloom size 12 × 10 in.

35 in. Mill — 5 passes: 3 — 1 — 1 } Total 12 passes. Same shape from 35 in. mill for beam and channel.
32 in. Mill — 7 passes: 3 — 3 — 1 }

European standard beams are similar in profile to their respective American size. The channels have flanges approximately ⅜ in. longer, thinner at the base, thicker at the toe with 6½ degree taper.

7. 270 mm channel
10.63 × 3.23 × 0.295 in.
Bloom size 11 × 8⅞ in.
35 in. Mill { 2 passes in No. 1 . . . . . 2 passes in No. 2 . . . . . 1 pass in No. 3 . . . . . } Total 12 passes.
32 in. Mill — 7 passes: 3 — 3 — 1

8.	200 mm beam	200 mm channel
	7.87 × 3.93 × 0.279 in.	7.87 × 2.82 × 0.275 in.
9.	220 mm beam	220 mm channel
	8.66 × 4.33 × 0.295 in.	8.66 × 3.03 × 0.275 in.
10.	240 mm beam	240 mm channel
	9.45 × 4.56 × 0.315 in.	9.45 × 3.07 × 0.278 in.

These sections are all made in a similar manner as previously described. Made in two weights.

11. 150 × 150 mm H-beam } American standard — Equivalent 6 in. H-beam.
5.90 × 5.90 in. . . . . }
Bloom size 11¾ × 6⅛ in.
35 in. Mill { No. 1 slab to 12 × 5 in. . . . . No. 2 through No. 1 blanking pass 1 . . . . . No. 3 slab . . . . . No. 4 through No. 1 blanking pass . . . . . No. 5 through No. 2 pass . . . No. 6 through No. 3 pass . . . No. 7 through No. 4 pass . . . } Total 14 passes.
32 in Mill — 7 passes: 3 — 3 — 1 . . . . . }

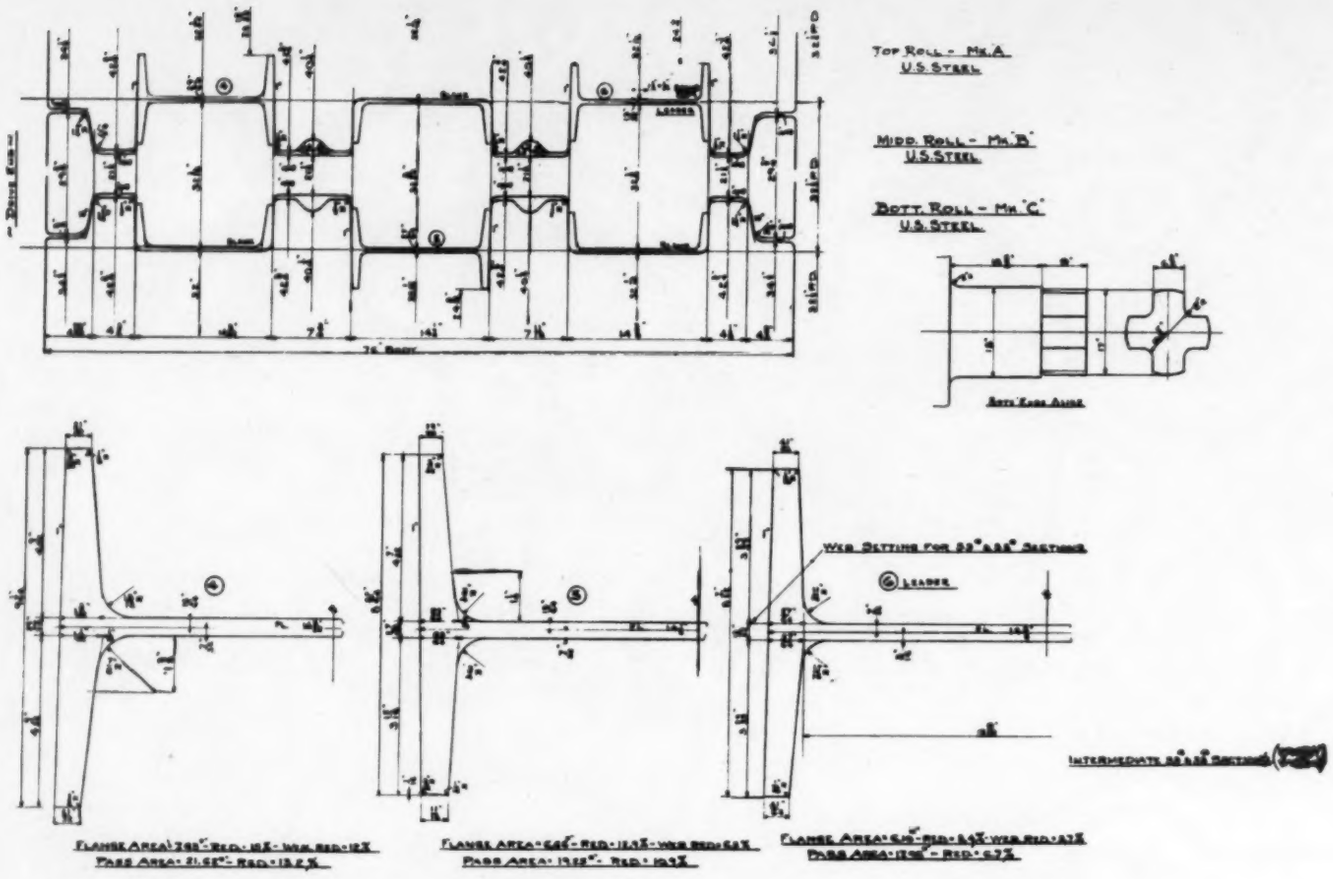


Figure 9 — The three-high intermediate mill has two sets of 32 x 76 in. rolls, one rolls the two heavy weights and the other rolls the two light weights. Shown here are the heavy weight passes.

12. 450 mm beam — 18 in. approximate American standard.
Made in three weights.
17.71 × 6.078 in.
Bloom size 16 × 13 in.
35 in. Mill { 5 passes through No. 1 groove; 1 pass through No. 2 groove.; 1 pass through No. 3 groove. } Total 14 passes.
32 in. Mill — 7 passes: 4 — 2 — 1 .....

13. 200 × 200 mm H-beam 7.87 × 7.87 in ..... { Approximate American standard — Equivalent 8 in. H-beam.
Bloom size 15¾ × 6⅞ in.
35 in. Mill { 4 passes through No. 1 blanking pass .....; 1 pass through No. 2 .....; 1 pass through No. 3 .....; 1 pass through No. 4 ..... } Total 14 passes.
32 in. Mill — 7 passes: 3 — 3 — 1 .....

14. 15. 16. We now come to three wide flange beam sections: 250 × 200 mm — 300 × 200 mm — 360 × 200 mm — 9.84 × 7.87 in. — 11.81 × 7.87 in. — 14.173 × 7.87 in.
since these are all made in a similar manner, a full description of the rolling procedure for the 14 × 8 in. will follow:

17. 500 mm beam..... 19.68 × 5.98 × 0.459 in. { Approximate American equivalent 20 in.
Made in three weights.
46 in. Mill — 28 × 28 in. ingot to beam blank — 18½ × 12 × 4 in. — 13 passes.
Crop, shear to length and reheat.
35 in. Mill { 3 passes through No. 1; 1 pass through No. 2.; 1 pass through No. 3. } Total 12 passes.
32 in. Mill — 7 passes: 4 — 2 — 1

18. 600 mm beam..... 23.62 × 6.98 × 0.519 in. { Approximate American equivalent 24 in.
Made in three weights.
46 in. Mill — 28 × 28 in. ingot to beam blank — 22½ × 12¾ × 4 in. — 11 passes.
Crop, shear to length and reheat.
35 in. Mill { 3 passes through No. 1; 2 passes through No. 2 } Total 14 passes.
32 in. Mill — 9 passes: 4 — 4 — 1

19. 400 × 175 mm wide flange beam 15.74 × 6.88 × 0.299 in..... { 16 × 7 in. approximate American equivalent.
46 in. Mill — 28 × 28 in. ingot to beam blank — 14½ × 13½ × 4 in. — 17 passes.
Crop, shear to length and reheat.
35 in. Mill { 2 passes through No. 1; 2 passes through No. 2; 1 pass through No. 3. } Total 12 passes — made in 4 weights.
32 in. Mill — 7 passes: 3 — 3 — 1

20. 530 × 210 mm..... 20.86 × 8.26 × 0.390 in. { wide flange beam 21 × 8¼ in. American equivalent.

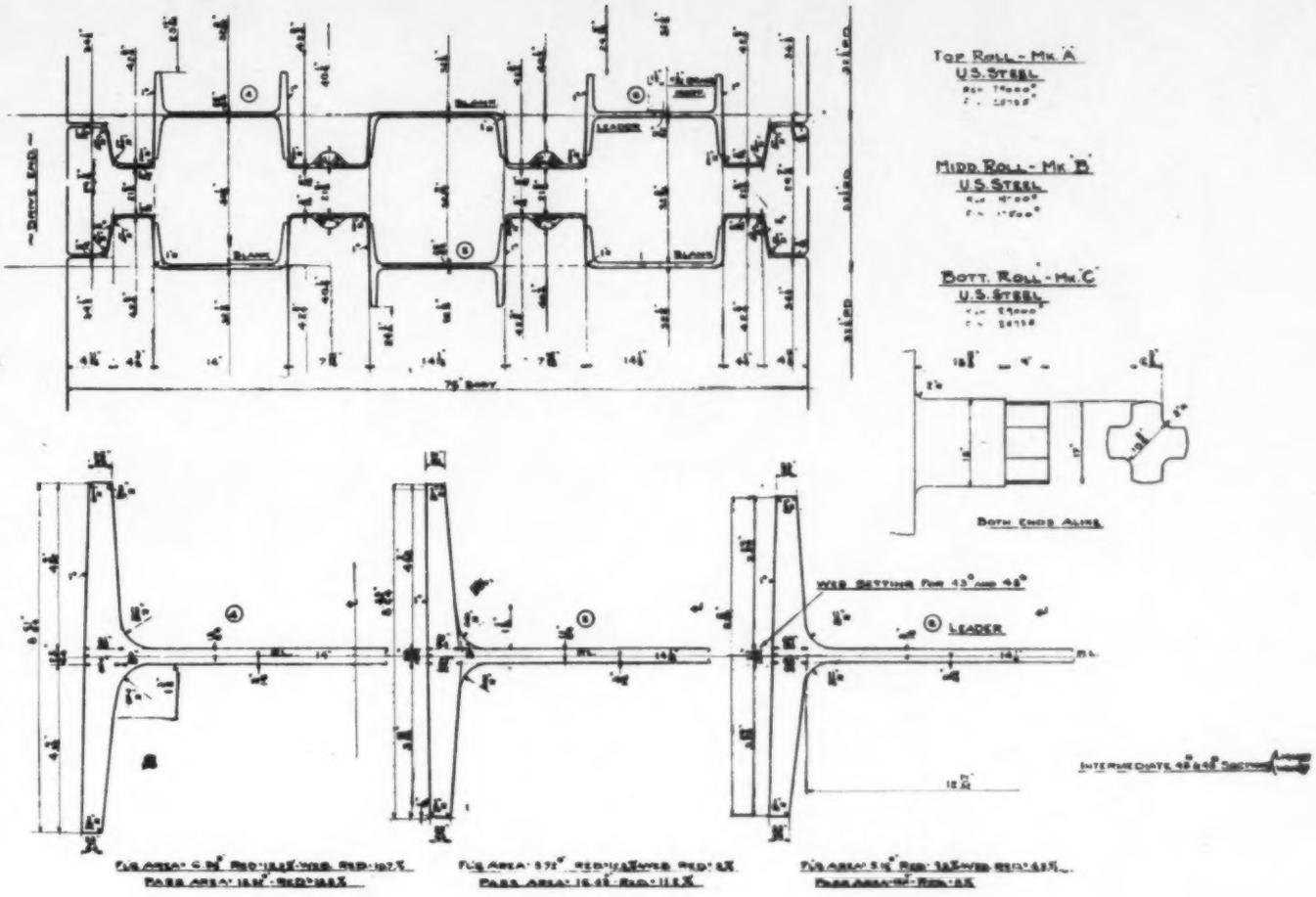


Figure 10 — This set of rolls, rolls the light weight sections corresponding to the heavy weight sections shown in Figure 9.

Made in 4 weights.

46 in. Mill — 28 × 28 in. ingot to beam blank — 19¾ × 15 × 4 in. — 15 passes.

Crop, shear to length and reheat.

35 in. Mill { 2 passes through No. 1
1 pass through No. 2.. } Total 10 passes.

32 in. Mill — 7 passes: 4 — 2 — 1

43.5 *Kilogram per meter rail* — As previously mentioned, the rolling proceedure and pass design for the rail and wide flange beam will now be described in detail. Sections of this type usually present greater problems to the operating personnel responsible for their production, and hence have been chosen to provide more interesting discussion.

The 43.5 kilogram per meter rail equals approximately 87.6 lb per yard, which is about equivalent to our 90 lb rail. Flange and web are lighter, while the head is about equal in area to a 112 lb rail. Ingots 26 × 24 in. weighing approximately 12,000 lb are rolled on the 46 in. bloomer to 11⅞ × 9½ in. blooms in 15 passes. When cropped and sheared to 14 ft lengths, one ingot provides two blooms weighing approximately 5400 lb each. These continue on through the reheating furnace after which they are rolled in the 35 and 32 in. mills to finished rail lengths approximately 175 ft long. Allowing for shrinkage crop and test piece, this length provides four 41 ft rails all cut simultaneously by five drop saws suitably located in the runout table line, thence continuing on through the cambering machine and hot bed.

Rail roll pass design — 35 in. mill — From the reheating furnace, the 11⅞ × 9½ in. × 5400 lb bloom enters the 35 in. breakdown mill. See Figure 3.

One pass is taken on the bullhead to 8¼ × 12¼ in. then turned into edging groove, squaring up to 8½ in. bloom in two passes. Bar is again turned and passed through No. 1 and No. 2 hat passes, after which it is conveyed to the 32 in. 3-high rougher.

32 in. mill, roughing — Approaching the 32 in. mill, with rolls 32½ × 76 in., bar is turned 90 degrees by means of the manipulator on the tilting table and given three passes in this set, see Figure 4.

No. 1 bottom, No. 2 top, then turning 90 degrees into No. 3 bottom or dummy pass.

Bar is then run off the stationary tilting table to the transfer table, which carries it across the mill to the intermediate stand.

32 in. mill, intermediate — From the dummy pass, bar is again turned 90 degrees and given three passes: top, bottom, top to No. 6 leader without further turning. Rolls are 32½ × 76 in. Duplicate grooves are provided for all three passes. See Figure 5.

32 in. mill, finishing — One pass through the finisher, rolls 32½ × 48 in., completes the cycle of bloom to finished rail bar in 12 passes. See Figure 6. This set is of the usual rail finisher type and needs no explanation.

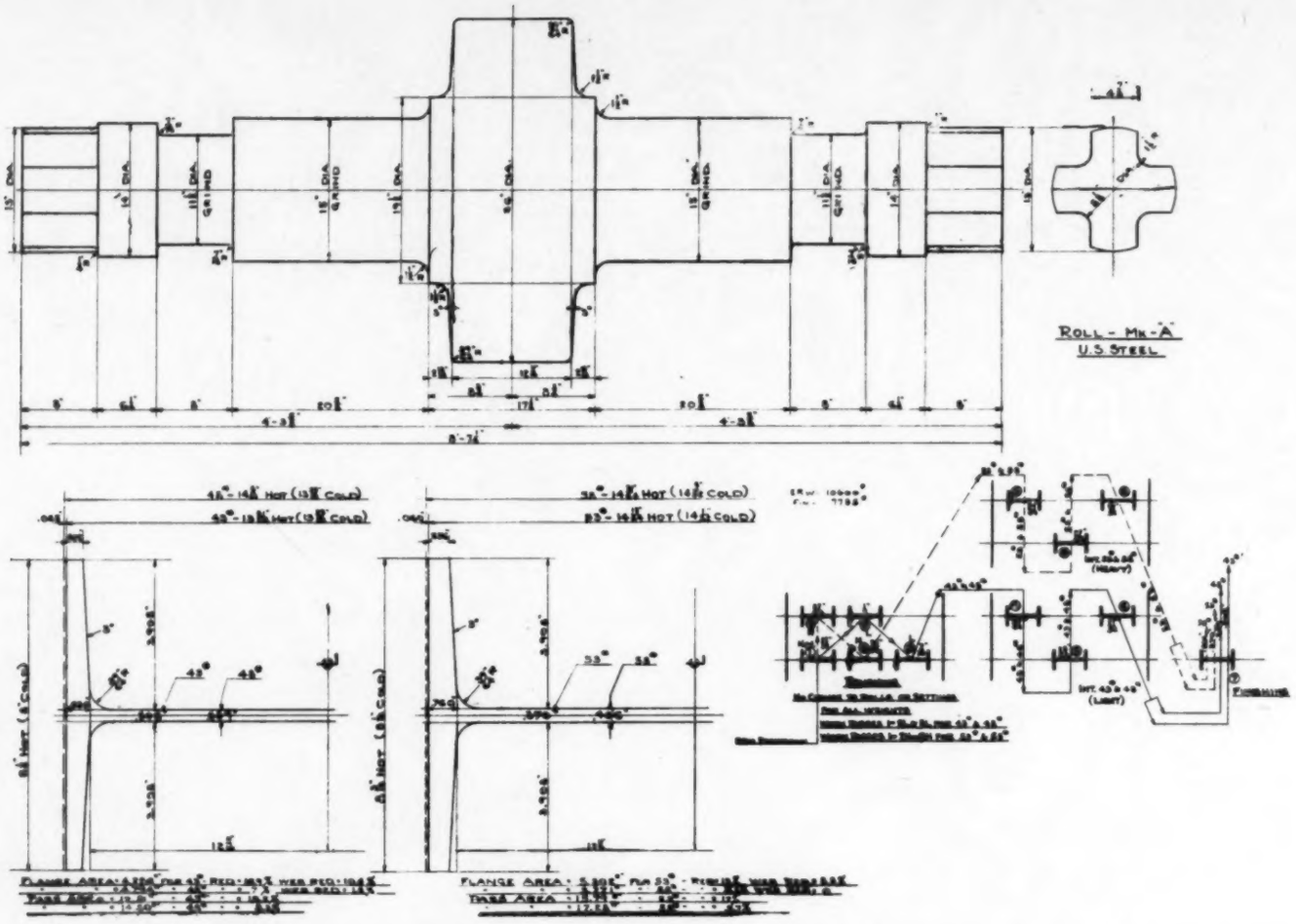


Figure 11 — Beam finishing rolls in 35 in. 2-high mill.

360 × 200 *mm or* 14 × 8 *in. wide flange beam* — Standard beam sections, as rolled on the mill previously described, are subject to a number of disadvantages. Outstanding among these are, limitation of flange width, thickness of web, and the degree of slope inside of the flanges. A further disadvantage is found in the low moment of inertia and section modulus referred to the vertical neutral axis. To overcome these difficulties, the wide flange beam was brought forth.

The field of application for these sections became a very extended one, and, in the course of years, a number of large mills were constructed for the exclusive purpose of rolling this product. Inasmuch as the mill under discussion was primarily designed for rail and standard structural sections, it could not be readily adapted to the rolling of wide flange beams (which customer requested) without the installation of some special equipment. By interchanging the conventional two-high with a heavy universal stand, this mill can successfully roll wide flange beams up to 21 × 8¼ in. with 3 degree taper.

The following illustrations and description will show, in detail, how this is accomplished.

The 14 × 8 in. beam, a popular section, is chosen for example.

35 in. two-high reversing breakdown rolls — Bloom 17 × 12 in. is entered into No. 1 blanking pass and given three successive reductions of 4 in. each, forming a blank 14¼ in. high × 12¾ in. wide × 5 in. web thickness. Rolls are 39¾ in. pitch diameter × 92 in. See Figure 7.

Blank is then shifted across the table to No. 2 pass, where two reductions of 2½ and 1⅛ in. are taken to a web thickness of 1⅜ in. Bar is then turned 180 degrees, given one pass in No. 3, turned again 180 degrees and given the final pass through No. 4; thus reducing the section to 13½ × 11⅝ × ¾ in. web in seven passes. This shape is delivered to the 32 in. three-high roughing and is used to produce the entire range of four weights. The roughing and intermediate sets are of the conventional design, as used in standard beam rolling.

Three high roughing — This set, consisting of five passes, although never more than three at one time are used, is designed to take care of all four weights without adjusting the web settings during rolling operations. Rolls are 32 × 76 in. See Figure 8.

No. 1 bottom — for all four weights..... 21.5 per cent reduction.
No. 2 directly above — for two heavy weights..... 6.0 per cent reduction.
No. 3 bottom center — for two heavy weights..... 12.5 per cent reduction.
No. 2 top center — for two light weights..... 16.5 per cent reduction.

No. 3 bottom right — for two light weights.....15.0 per cent reduction.

From the foregoing it can readily be seen that using the same No. 1 for all four weights necessitates heavier drafts on the light weight passes, but none exceed 21.5 per cent.

Three high intermediate — Two sets of intermediate rolls 32 × 76 in. are provided, each consisting of three passes, numbered 4, 5, 6. See Figures 9 and 10. One set rolls the two heavy weights and the additional set covers the two lighter weights, with reductions as follows:

Heavy weights —	Light weights —
53 and 58 lb per foot	43 and 48 lb per foot
No. 4 — 13 per cent reduction.	14 per cent reduction.
No. 5 — 11 per cent reduction.	11 per cent reduction.
No. 6 — 7 per cent reduction.	8 per cent reduction.

A roll change in the intermediate stand is therefore necessary, and this may be quickly accomplished by interchanging the housing stand on the build-up floor with that in the mill.

In each of these sets, No. 6 is the leader pass and is designed to permit the rolling of two weights without a corresponding adjustment of the rolls for web thickness. This is primarily a sizing pass, with uniform thickness of flanges, centralized about the web, while finishing the toes which receive no further work.

For the final, or seventh pass, bar is transferred to the 2-high universal beam finishing mill which, as previously stated, is interchangeable with the conventional 2-high stand.

This mill consists of two driven horizontal rolls 36 in. diameter with top or bottom screw adjustment and two vertical friction rolls 31 in. diameter × 10½ in. face all in the same plane. Vertical rolls are in self-contained adjustable units, each having a single roller bearing 18¾ in. outside diameter mounted on stationary shaft 11½ in. diameter. Roll housing centers are adjustable by four groups of separators of various lengths, to accommodate the entire range of beams.

Figure 11 shows the rolling diagram and method of finishing the various weights. In the case of wide flange beam sections, increased foot weight is obtained by the addition of web thickness with a proportional increase in flange thickness. As previously stated, two weights are finished from one leader having sufficient flange and web thickness to produce the heavier of the two. Thus the heaviest reduction is taken on the lighter foot weight section. This is not excessive and amounts to approximately $^{1}/_{37}$ in. on web and $^{3}/_{32}$ in. on flange thickness, or approximately 15 per cent. Drafts for the remaining weights are proportionately lower, due to increased thickness of web and flange.

Summarizing the rolling schedule illustrated, we have seven passes in the 35 in. breakdown mill, three roughing and three intermediate passes in the 32 in. 3-high mills, and one in the 36 in. universal mill; making a total of 14 passes from bloom to finished beam.

DISCUSSION

PRESENTED BY

H. A. CARTER, Superintendent Rolling Department, Bethlehem Steel Company, Lackawanna, New York

H. F. VOIGT, United Engineering and Foundry Company, Pittsburgh, Pennsylvania

C. J. PORTER, Electrical Engineer, The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

E. A. OSGOOD, Superintendent, Structural Mills, Bethlehem Steel Company, Lackawanna, New York

H. A. Carter: Are you sure that your rotary straightener will straighten rails satisfactorily for the trade?

H. F. Voigt: We understand that in manufacturing rails in various parts of Europe, specifically Germany and England, it is common practice to straighten rails by the rotary type straightener. Likewise, Japan straightens rails in this manner. Many years ago we straightened rails by the rotary straightener but as the rail sizes increased apparently the existing roller straighteners were not large enough.

H. A. Carter: Will the roller straightener take care of the ends of each rail? It has been our experience when straightening structural on a rotary straightener, that the ends of material require some gagging to take care of ends.

H. F. Voigt: That is correct. The front and back end of each rail length, requires gag straightening after it has been machine straightened. However, where you may be taking 8 to 12 blows now to straighten, we expect that this method will require a maximum of 6 blows.

H. A. Carter: Would you recommend that we straighten rails in a rotary straightener, in this country?

H. F. Voigt: Yes.

C. J. Porter: Your paper, Mr. Voigt, has dealt almost entirely with the mechanical features of the mill you have described. Could you give us an idea of the extent to which the Ward-Leonard system of control has been applied to the large number of main and auxiliary drives throughout the mill?

H. F. Voigt: Practically all have Ward-Leonard control.

E. A. Osgood: Is the 28 in. mill finisher, when equipped with vertical rolls for rolling H-piling sections, separately driven, driven by one spindle from the intermediate, or normally driven from the bottom and middle intermediate rolls?

H. F. Voigt: This universal mill for rolling H beam sections is separately motor driven.

REMOTE CONTROL OF CONTINUOUS *Slab Heating Furnaces*

. . . . a good control installation requires accessibility, complete coverage, protection of product, and adequate protection and maintenance of the control devices . . . .

By C. E. DUFFY
Assistant Fuel Engineer
Bethlehem Steel Company
Sparrows Point, Maryland

▲ THE 56 in. hot strip mill at the Sparrows Point plant of Bethlehem Steel Company is provided with four 18 ft × 80 ft triple-zone continuous slab-heating furnaces. When the mill was built in 1937, three furnaces were installed, the fourth being added in 1945.

The heating of slabs to rolling temperatures of 1850-1950 F is accomplished in three separate heating zones, Figure 1, a top zone, a bottom zone, and a soaking zone. The temperature of the top zone is maintained at 2600 F and that of the soaking zone at 2400 F. Each zone has its own fuel and combustion-air supply.

The waste gases are drawn from the charging end of the furnace, shown in Figure 2, through a refractory recuperator and are discharged to a brick-lined steel stack. The combustion air is drawn through the recuperator by a 20,000 cfm hot-air fan, discharged into three separate headers, measured, and delivered to the three heating zones of the furnace.

The furnaces are equipped to burn either Bunker "C" fuel oil or coke-oven gas through burners, as shown in Figure 3. Oil is the basic fuel and coke gas is used only when there is a surplus in the plant's gas balance. The fuel oil pumping, storage, and conditioning system is shown in Figure 4. Fuel oil is taken from the storage tank by a motor-driven pump, passed through a filter into five oil heaters arranged in parallel and then to the control manifolds and burners for each zone. A relief valve permits some oil to bypass the controls and the furnaces, and return to the storage tank. This is done to keep a flow of oil through the entire system at all times and to eliminate the necessity of steam tracer lines. The storage tank receives oil from the main line, supplying fuel oil to that division of the plant. A float valve controls the oil level in the storage tank.

The control and metering system for fuel oil is shown in Figure 5. This equipment is located in the basement below the furnaces. The fuel passes through an oil strainer, a meter body, an oil static transmitter, and a diaphragm-operated flow-control valve. Suitable bypasses are provided so that any unit can be serviced without interrupting the flow of oil to the various heating zones.

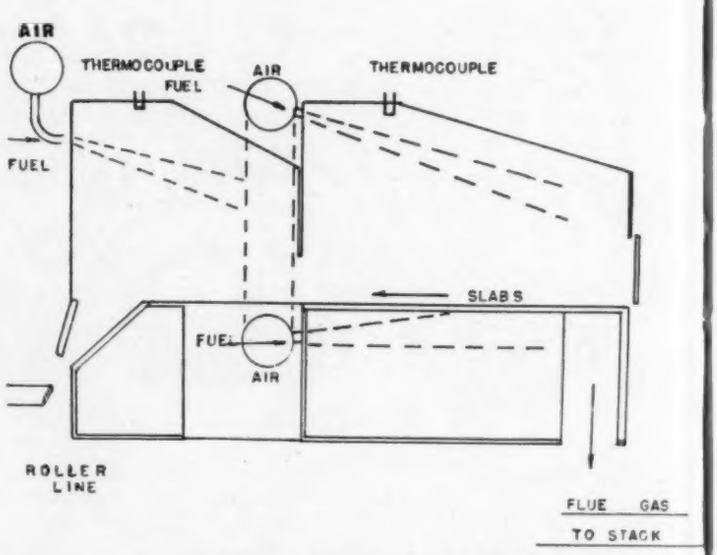


Figure 1 — A top zone, a bottom zone, and a soaking zone are used in heating the slabs to rolling temperatures.

A constant furnace pressure is maintained in the soaking zone by means of a hydraulic furnace-pressure control operating a stack damper, shown in Figure 6, in the flue leading from the recuperator to the stack.

In 1937, when the installation of the three original furnaces was made, the control equipment and instruments were installed in individual control houses, located between the furnaces; shown in Figure 7. This location proved to be unsatisfactory both from the operating and the maintenance department's standpoint. The furnace operator had to walk continually from one control house to another to observe the conditions for the various zones of the three furnaces. The area between the furnaces was too warm for efficient

Presented before AISE Annual Spring Conference, Philadelphia, Penna., May 26, 1947

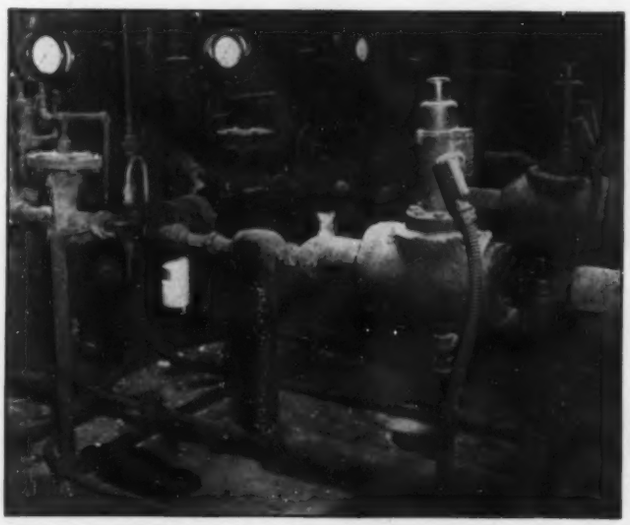
Figure 2 — Waste gases from the charging end of the furnace go through a refractory recuperator before discharge through the stack.

Figure 3 — The burners can burn either fuel oil or coke-oven gas.

Figure 4 — Fuel oil pumping, storage, and conditioning system.

Figure 6 — A stack damper, operated by hydraulic furnace-pressure control, maintains constant pressure in the soaking zone.

Figure 5 — The control and metering system for fuel oil is located in the basement below the furnaces.



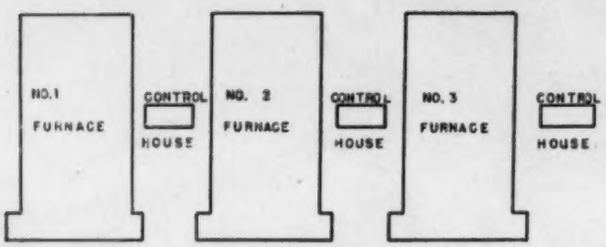


Figure 7 — This sketch shows the previous location of the control houses adjacent to the furnaces.

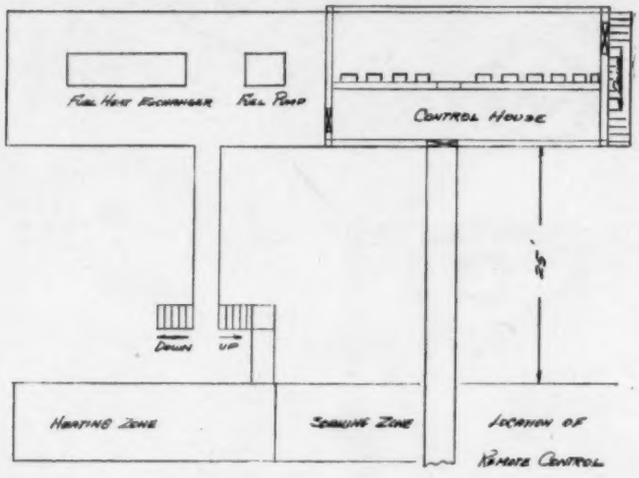


Figure 8 — The control house for the furnace is now located at some distance away from the furnaces.

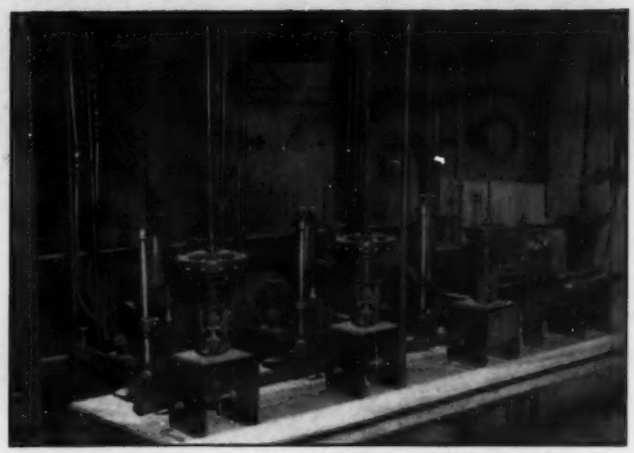


Figure 9 — Fuel-air ratio regulators.

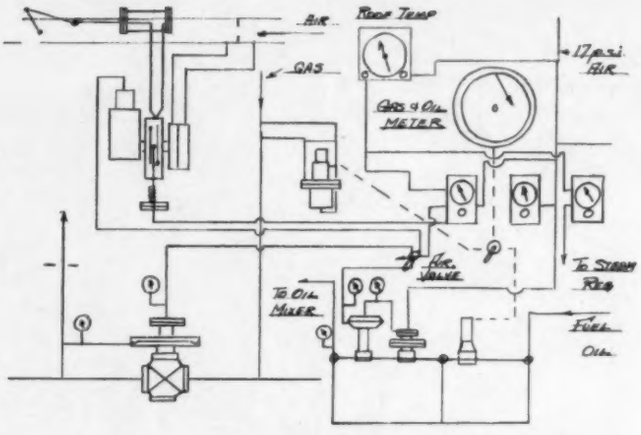
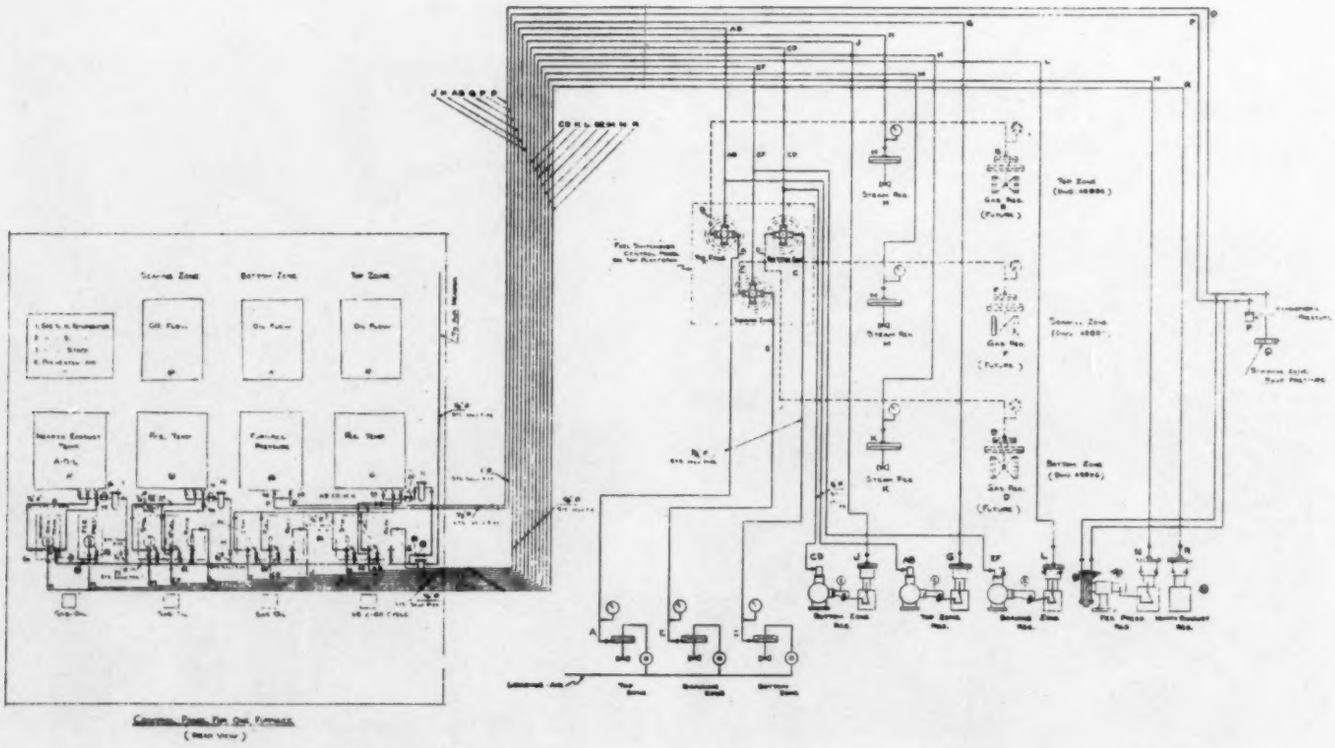


Figure 10 (Above) — Schematic arrangement of fuel and combustion control equipment for one zone.

Figure 11 (Below) — Typical piping diagram for one furnace.



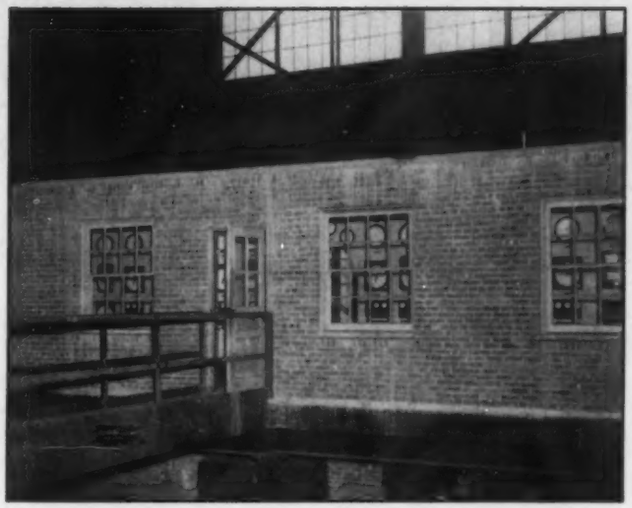
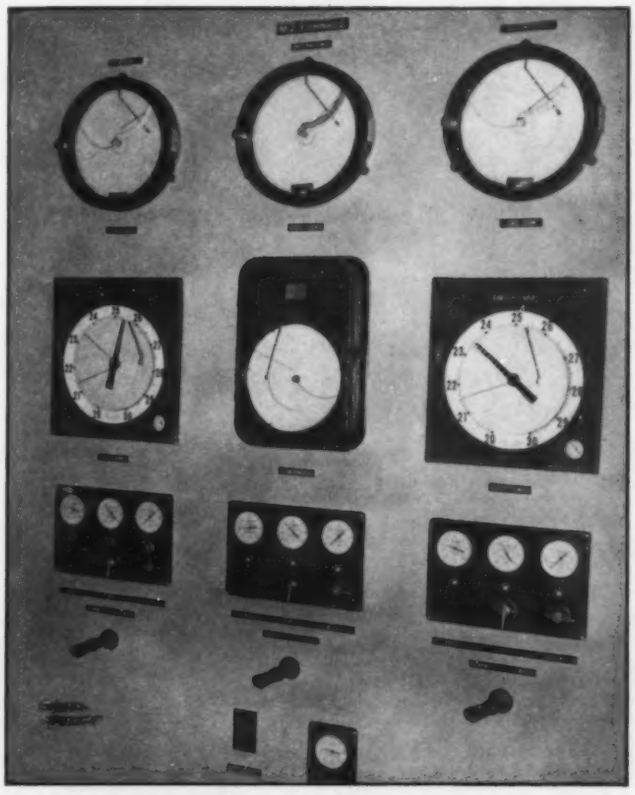


Figure 12 — Controls for four furnaces are in one control house.

operation and maintenance of the instruments and controls.

When the installation of the fourth furnace was planned in 1945, it was decided to move all instruments and controls away from the overheated area between the furnaces to one central control house located some distance away. Figure 8 shows the relative location of this central control house in respect to the furnaces. At the same time, temperature control was installed on both the soaking and the heating zones, so that manual fuel input to each zone could be made automatic. All

Figure 13 — Control panel for No. 2 furnace.



control regulators are now air-loaded from the central control house.

The temperature control consists of platinum-platinum rhodium thermocouples located in the roof of both the soaking zone and the top zone. The thermocouples are protected by a closed-end sillimanite tube encased in an open-end carborundum tube. The impulse from the thermocouples is transmitted to electronic pneumatic controllers which in turn send an air impulse to the fuel flow regulator for their respective zones. Fuel input to the bottom zone is controlled by the same impulse, that is used for top-zone firing.

The fuel-air ratio regulators shown in Figure 9 are located on a platform near the bottom-zone burner manifold. Each regulator is provided with a special diaphragm-operated mechanism for remote pneumatic control of the ratio setting.

Figure 10 shows a schematic arrangement of the fuel and combustion control equipment for one zone. Note, the roof temperature controller sends an air impulse through a manual-automatic control panel to the combustion air regulator and to a transfer valve, which is set for either fuel oil or for gas firing. When fuel oil is being used, the impulse goes to the flow diaphragm

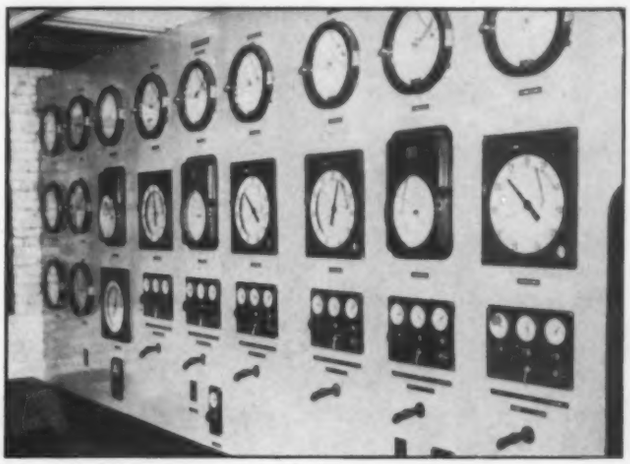


Figure 14 — Overall view of control panel.

valve. This valve in turn is balanced by an impulse from the oil static which also sends an impulse to the fuel-air ratio regulator.

In this manner any deviation in the temperature of any zone is instantly compensated for by a change in the fuel and air input to that zone. All controls are provided with manual-automatic control panels, so that maintenance work can be done at any time without upsetting the flow of the fuel or air to the furnace.

The furnace-pressure regulator with a remotely operated diaphragm mechanism is mounted on the same platform as the fuel-air ratio regulators. A pressure of 0.07 inches water is maintained in the soaking zone to eliminate as much air infiltration as possible through the furnace discharge doors.

Figure 11 shows a typical piping diagram for one furnace.

The control house, Figure 12, contains all of the controls and instruments for the four furnaces. This

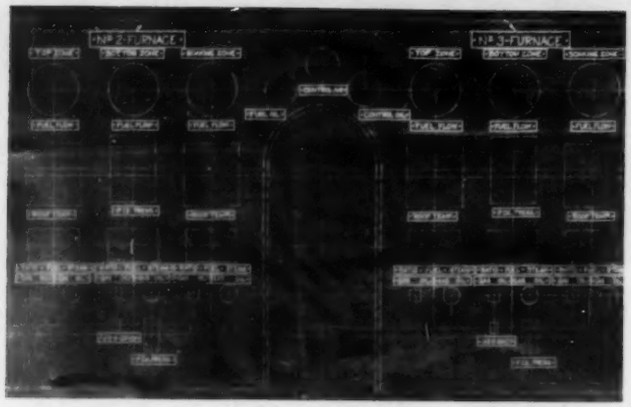


Figure 15 — Layout used in locating instruments and controls.

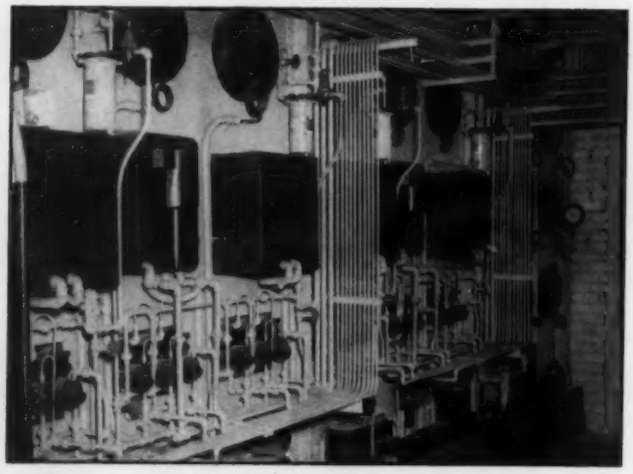
house has windows both at the front and the rear making it ideal for the operation and maintenance of equipment. Sections of the panel board are shown in Figures 13, 14 and 15. Figure 13 shows the zone divisions for one furnace. The top row of instruments are the fuel flow meters for the respective zones. Directly under these meters are the roof-temperature and furnace-pressure recorders. Next are the manual-automatic control panels, and underneath are the gas-oil switchover valves. Mounted over the opening in the center of the panel are the instruments common to all four furnaces, indicating pressure gages for fuel oil, control oil, and control air, Figure 15. Located on one end of the panel is a quick-response temperature-recording instrument, which shows the temperature of the slabs leaving the scale breaker. This instrument is provided with a system of signal lights, mounted near the roller's pulpit so that the roller is given an indication of the temperature of the slab being delivered to the mill.

A rear view of a section of the panel board showing piping to the instruments and controls is given in Figure 16.

In conclusion, the relocation of the instruments and controls to a central control house and the addition of zone-temperature control has shown the following advantages:

1. It has provided a modern, uniform control system for all furnaces, thus enabling the heater to check easily and quickly all furnace conditions from one central station.
2. It has guaranteed regular and even heating. In the case of four furnaces operating in parallel, it is extremely difficult to obtain uniform heating without automatic zone-temperature control.
3. It has prevented occasional overheating which oxidizes steel, causes scale to build up rapidly on the hearth, wastes fuel and increases furnace and hearth maintenance.
4. It has improved the operation of the controls and instruments and simplified the maintenance problem.

Figure 16 — Rear view of instrument panel board.



DISCUSSION

PRESENTED BY:

JOHN F. BLACK, General Superintendent, Wickwire Spencer Steel Division, Colorado Fuel and Iron Corporation, Buffalo, New York

C. E. DUFFY, Assistant Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

MARTIN CONWAY, Consulting Engineer, Gap, Pennsylvania

R. A. LAMBERT, Assistant Superintendent, Steam and Combustion, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

John F. Black: I note that you speak of zone control. Am I to understand that you have the same amount of fuel on both zones, top and bottom, at the present time?

C. E. Duffy: Perhaps I did not make myself clear on that point. The top zone roof temperature controller sends an impulse to both the top and the bottom zone fuel control. However, the bottom zone control is set so that the maximum oil input is 300 gallons per hour; the top zone 360 gallons per hour.

John F. Black: What are the air temperatures? It is very seldom that anything is said of air temperatures on the slab heater. Do you know what the air temperature coming from the recuperators would be?

C. E. Duffy: We are averaging between 400 and 500 degrees F.

John F. Black: I understand you have a rather original setup to keep the heater out of the hot area between the furnaces. Some one has said you have a peep hole situated so the heater can observe the slabs without going to the side of the furnaces. Can you say anything about that?

C. E. Duffy: Under the old arrangement, every time a slab was pushed from the furnace, the heater opened a side door, to watch the slab being pushed out,

and as the slab started down the pushout incline, the heater signaled the pusher operator to stop pushing. When all controls were moved away from the area between the furnaces, there was no one to watch the slabs being pushed and to signal the pusher operator, hence occasionally slabs were pushed too far, and the result was that the second slab would slide down the pushout incline after the discharge doors had been closed. This caused severe damage to the discharge doors. We have now installed a set of refractory tubes through the front wall of the furnace. These tubes are sighted at the joint between the hearth and discharge incline. The end of the tube outside of the furnace is provided with a blue glass which is kept clean by a jet of low pressure air. The heater can now stand on the furnace walkway, watch the slabs and signal the pusher operator.

John F. Black: I cannot help but comment on certain things I have observed. I once had a chance to observe these furnaces, when they were installed. I cannot help but feel that this new location of the panel board is smart, and a means of keeping the heater comfortable. I can recall the panel boards in the old locations, particularly on a day in the hot Maryland summertime, when we had a temperature of around 150 F between the furnaces. In fact it was so hot, you could hardly live in there. It was necessary to open up the back of the panel board and play compressed air in on the controls, particularly the electrical controls to keep them operating. It would get too hot to operate, and the heater had to race up and down the steps to each furnace to get to his controls. The result was it was a bit hard in hot weather to maintain the heater's interest in the control. He would get out on the open soak zone platform and stay there, so I think that beautiful panel board was probably not hard to sell, particularly the location of it. It is smarter and it certainly should make for a better operation.

Mr. Duffy sums up the cardinal requisites of a good control installation in the close of his paper:

1. Accessibility.
2. Complete coverage, by controlling all operations which are subject to variation.
3. Protection of the product during varying rates of heating, with a minimum fuel consumption.
4. Adequate protection and maintenance of the control devices which serve the foregoing purposes.

R. A. Lambert: I should like to ask Mr. Duffy if the operating personnel was increased when the change from three furnaces to four, was made?

C. E. Duffy: No increase.

R. A. Lambert: Could you tell us what the production rate is, that is the maximum hourly production rate, and also the average eight hour production rate? Was there any increase in the rate when you moved your control panels to one single control location?

C. E. Duffy: Approximately 50 tons per furnace per hour.

R. A. Lambert: Then you did not necessarily get any greater production rate per furnace when you went to four furnaces? In other words, your savings were in the maintenance, which is admittedly large, and also the hours spent on maintenance.

C. E. Duffy: We are now getting a more uniform temperature at all times.

R. A. Lambert: Another question I should like to ask is this. We have similar furnaces in the Pittsburgh plant, and when we keep the bottom zones on liquid fuel, we have tremendous trouble with slag build-up in the downtakes. Do you have the same difficulty?

C. E. Duffy: I would not say we have any particular trouble with slag build-up. Three or four years ago we had a little trouble with hot skids, but this difficulty has been cleared up.

R. A. Lambert: Our trouble is that the slag gets very solidified in there, and reduces the effect of the combustion chamber at the bottom zone, and we find it extremely difficult to burn liquid fuel. Until recently we were operating on pitch, which fuel is even a little more difficult to burn than oil.

I was interested in the control you were using, and the platinum-rhodium couples. I wondered why you did not go to a radiation pyrometer design.

C. E. Duffy: At that time we had not had much experience with that design. It is merely a matter of choice, and either should work satisfactorily.

R. A. Lambert: Would you tell us something about the liquid fuel burners, whether the atomizer is on the inlet end of the burner, or whether the atomizer is at the hot tip of the burner, or otherwise.

C. E. Duffy: We use one atomizer for a whole zone. We have a steam-oil mixer outside of the furnace, and then as many pipes leading from that mixer as we have burners. On some zones, we have six burners, and on some we have eight.

R. A. Lambert: Do you have any trouble with the pushers covering up the exit flues, at the cold end of the hearth, so that the waste gases cannot get down in the recuperators?

C. E. Duffy: Yes.

R. A. Lambert: We have the same difficulty.

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IN EACH AND EVERY ISSUE

AISE STANDARD NO. 1

D-C MILL MOTOR STANDARDS

1. General

   a. The development of the AISE mill motor standards is outlined in the 1926, 1928-29, 1940 and 1947 Proceedings of the Association of Iron and Steel Engineers.

   b. The standard d-c mill motor is the short frame motor as detailed on the accompanying Table I and Figures 1 and 2. The present AISE motors (Frames 3-18 inclusive) will be an alternate standard which will be in effect as long as they are built as a standard line by the motor manufacturers, and after that time will be a standard for replacements only. The present AISE Frame 2, 5 hp, (1 hr 75 C totally enclosed rating) will continue as the standard 5 hp motor.

2. Ratings:

   a. The basic 1 hr 75 C totally enclosed ratings of the standard line will be as follows: 5 hp, 7½ hp, 10 hp, 15 hp, 25 hp, 35 hp, 50 hp, 75 hp, 100 hp, 150 hp, and 200 hp. The rating which is added is the 200 hp. Other ratings and data will be as given in Table I.

3. Dimensions:

   a. The outline dimensions of the standard line of short frame motors will be as shown in Figure 1.

4. Back axle details:

   a. Details of the back axle bearing construction are shown in Figure 2.

5. Tolerances:

   a. The sides of the motor feet, parallel to the shaft, are machined to the tolerances shown in Figure 1. A standard tolerance is also shown for the height from the bottom of the motor feet to the centerline of the armature shaft.

Table I — AISE Standardized D-C Mill Motor Ratings.

AISE MOTOR FRAME	TOTALLY ENCLOSED								PROTECTED SELF-VENTILATED								TOTALLY ENCLOSED AND PROTECTED SELF-VENTILATED								
	1 HOUR, 75 DEG. C. RISE				5 HOURS, 75 DEG. C. RISE				CONTINUOUS, 75 DEG. C. RISE				1 HOUR, 75 DEG. C. RISE				TORQUE IN POUNDS AT 1 FOOT RADIUS								
	HP	RPM			HP	RPM			HP	RPM			HP	RPM			1 HOUR, 75° C., RISE			MAX. STARTING*			MAX. RUNNING†		
		SERIES	COMPOUND	SHUNT		SERIES	COMPOUND	SHUNT		SERIES	COMPOUND	SHUNT		SERIES	COMPOUND	SHUNT	SERIES	COMPOUND	SHUNT	SERIES	COMPOUND	SHUNT	SERIES	COMPOUND	SHUNT
230 VOLTS																									
# 2	5	900	1025	1025	3 1/2	1080	1200	1100									29	25.5	25.5	145	115	92	116	90	75
602	7 1/2	800	900	900	4 1/2	1065	1050	955	7 1/2	802	900	900	9 1/4	780	800	885	49	44	44	245	198	158	196	154	138
603	10	725	800	800	6	950	925	840	10	725	800	800	12 1/2	645	725	785	72	65.5	65.5	360	295	235	288	230	195
604	15	650	725	725	7 1/2	1025	885	770	15	650	725	725	19	560	650	710	121	109	109	605	490	390	484	382	325
606	25	575	650	650	13	800	785	685	25	575	650	650	31 1/2	525	635	650	228	202	202	1140	910	730	912	710	600
608	35	525	575	575	18	740	675	600	35	525	575	575	44	475	540	575	350	320	320	1750	1440	1150	1400	1120	960
610	50	500	550	550	22 1/2	720	640	565	50	500	550	550	62 1/2	460	510	550	525	477	477	2625	2150	1720	2100	1670	1430
612	75	475	515	515	27	700	600	525	75	475	515	515	94	435	485	515	830	765	765	4150	3440	2750	3320	2700	2290
614	100	460	485	485	46	685	550	505	100	460	485	485	125	425	450	485	1140	1080	1080	5700	4860	3890	4560	3780	3240
616	150	450	460	460	66	675	520	480	150	450	460	460	187 1/2	410	440	460	1750	1710	1710	8750	7700	6150	7000	6000	5130
618	200	410	420	420	85	650	500	430	200	410	420	420	250	380	400	420	2560	2500	2500	12800	11250	8500	10000	9000	7000
550 VOLTS																									
# 2	5	1015	1150	1150	3 1/2	1270	1300	1200									26	23	23	105	85	70	90	65	60
602	7 1/2	935	1045	1025	4 1/2	1210	1185	1050	7 1/2	935	1025	1025	9 1/4	825	925	1015	42	38	38	170	135	115	145	105	95
603	10	810	885	885	6	1115	1025	920	10	810	885	885	12 1/2	725	800	875	65	59	59	260	210	175	230	165	150
604	15	725	800	800	7 1/2	1060	1000	850	15	725	800	800	19	635	750	785	109	98	98	435	350	295	380	275	245
606	25	635	700	700	13	985	850	735	25	635	700	700	31 1/2	575	675	685	207	188	188	830	675	565	725	585	470
608	35	585	625	625	18	850	735	650	35	585	625	625	44	525	585	610	314	294	294	1255	1060	880	1100	825	735
610	50	530	585	585	22 1/2	750	700	600	50	530	585	585	62 1/2	475	560	575	495	449	449	1980	1615	1345	1735	1255	1125
612	75	510	550	550	27	740	635	570	75	510	550	550	94	465	515	540	772	716	716	3090	2580	2150	2700	2000	1790
614	100	475	500	500	46	710	575	525	100	475	500	500	125	440	475	490	1105	1050	1050	4420	3780	3150	3870	2940	2625
616	150	460	460	460	66	675	520	480	150	460	460	460	187 1/2	425	440	450	1710	1710	1710	6850	6170	5135	6000	4800	4280
618	200	415	415	415	85	650	500	430	200	415	415	415	250	380	400	415	2530	2530	2530	10100	9100	7600	8800	7000	6300

ADJUSTABLE SPEED DIRECT CURRENT MILL MOTORS	
SHUNT OR STABILIZED SHUNT WOUND	
AISE MOTOR FRAME	1 HOUR, 75 DEG. C., ENCLOSED CONT., 75° C., SELF-VENTILATED HP — RPM
230 VOLTS	
# 2	5 — 1065/2050
602	7 1/2 — 900/1800
603	10 — 800/2000
604	15 — 725/1800
606	25 — 650/1950
608	35 — 575/1725
610	50 — 550/1650
612	75 — 515/1300
614	100 — 485/1200
616	150 — 460/1150
618	200 — 420/1050

* THE VALUES FOR MAXIMUM STARTING TORQUE ARE BASED ON THE FOLLOWING APPROXIMATE RATIOS TO THE CORRESPONDING 1 HOUR TOTALLY ENCLOSED TORQUE RATINGS:

	APPROX. RATIO OF MAX. STARTING TORQ TO 1 HOUR ENCLOSED TORQUE		
VOLTS	SERIES	COMPOUND	SHUNT
230	5	4.5	3.6
550	4	3.6	3

† THE VALUES FOR MAXIMUM RUNNING TORQUE ARE BASED ON THE FOLLOWING APPROXIMATE RATIOS TO THE CORRESPONDING 1 HOUR TOTALLY ENCLOSED TORQUE RATINGS:

	APPROX. RATIO OF MAX. RUNNING TORQUE TO 1 HOUR ENCLOSED TORQUE		
VOLTS	SERIES	COMPOUND	SHUNT
230	4	3.5	3
550	3.5	2.8	2.5

ENCLOSED FORCE-VENTILATED DIRECT CURRENT MILL MOTORS		
SERIES, COMPOUND, SHUNT & STABILIZED SHUNT WOUND		
230 & 550 VOLTS		
THE CONTINUOUS, 75 DEG. C. RISE RATINGS OF ENCLOSED FORCE-VENTILATED MOTORS ARE EQUAL TO THE 1 HOUR, 75 DEG. C. RISE TOTALLY ENCLOSED RATINGS WHEN THE REQUIRED VOLUME OF VENTILATING AIR FOR SUCH RATINGS IS SUPPLIED TO THE MOTORS.		
AISE MOTOR FRAME	REQUIRED CFM AIR	STATIC PRESSURE INCHES OF WATER AT MOTOR INLET
# 2	110	1
602	160	1/2
603	200	1/2
604	250	1/2
606	335	3/4
608	425	3/4
610	525	1
612	750	1 1/2
614	900	1
616	1200	1 1/4
618	1600	1 1/2

NOTES:-

† AISE FRAME 2, 5HP (60 MINUTE RATING) IS CARRIED OVER FROM PREVIOUS AISE MILL MOTOR STANDARD

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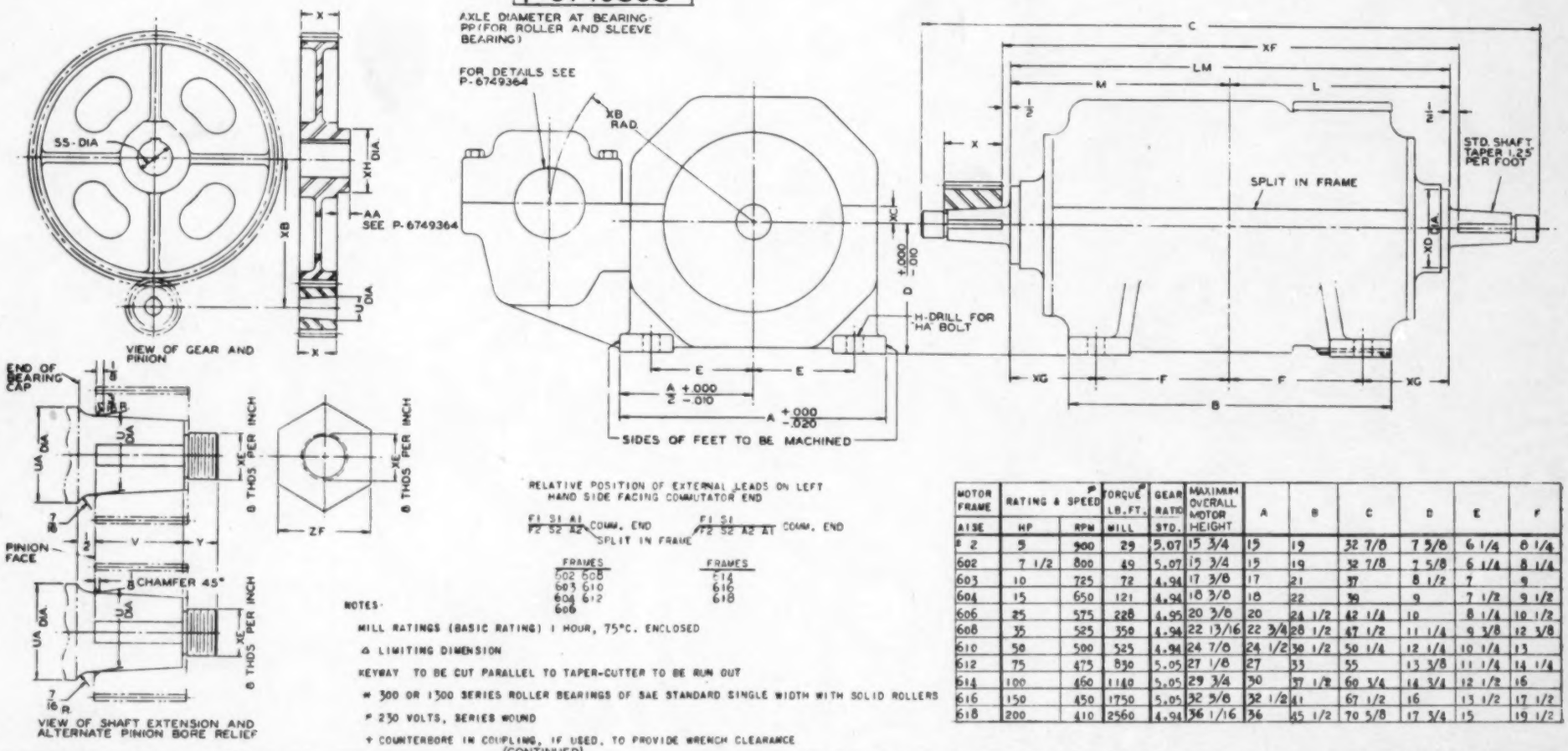

RELATIVE POSITION OF EXTERNAL LEADS ON LEFT HAND SIDE FACING COMMUTATOR END

F1 S1 A1 / F2 S2 A2 — COMM. END — SPLIT IN FRAME — F1 S1 / F2 S2 A2 A1 — COMM. END

FRAMES	FRAMES
602 608	F14
603 610	616
604 612	618
606	

NOTES:

MILL RATINGS (BASIC RATING) 1 HOUR, 75°C. ENCLOSED

Δ LIMITING DIMENSION

KEYWAY TO BE CUT PARALLEL TO TAPER-CUTTER TO BE RUN OUT

300 OR 1300 SERIES ROLLER BEARINGS OF SAE STANDARD SINGLE WIDTH WITH SOLID ROLLERS

P 230 VOLTS, SERIES WOUND

+ COUNTERBORE IN COUPLING, IF USED, TO PROVIDE WRENCH CLEARANCE

MOTOR FRAME AISE	RATING & SPEED P HP	RPM	TORQUE LB.FT. MILL	GEAR RATIO STD.	MAXIMUM OVERALL MOTOR HEIGHT	A	B	C	D	E	F
$ 2	5	900	29	5.07	15 3/4	15	19	32 7/8	7 5/8	6 1/4	8 1/4
602	7 1/2	800	49	5.07	15 3/4	15	19	32 7/8	7 5/8	6 1/4	8 1/4
603	10	725	72	4.94	17 3/8	17	21	37	8 1/2	7	9
604	15	650	121	4.94	18 3/8	18	22	39	9	7 1/2	9 1/2
606	25	575	228	4.95	20 3/8	20	24 1/2	42 1/4	10	8 1/4	10 1/2
608	35	525	350	4.94	22 13/16	22 3/4	28 1/2	47 1/2	11 1/4	9 3/8	12 3/8
610	50	500	525	4.94	24 7/8	24 1/2	30 1/2	50 1/4	12 1/4	10 1/4	13
612	75	475	830	5.05	27 1/8	27	33	55	13 3/8	11 1/4	14 1/4
614	100	460	1140	5.05	29 3/4	30	37 1/2	60 3/4	14 3/4	12 1/2	16
616	150	450	1750	5.05	32 5/8	32 1/2	41	67 1/2	16	13 1/2	17 1/2
618	200	410	2560	4.94	36 1/16	36	45 1/2	70 5/8	17 3/4	15	19 1/2

(CONTINUED)

MOTOR FRAME AISE	H	HA	L	M	LM	PP +.0000 -.0005	SS	U	UA	V	WD +	XB	XC	XD	XE	XF	XG	XH	Y	ZF	ARMATURE SHAFT KEY WIDTH	ARMATURE SHAFT KEY HEIGHT	AXLE SHAFT KEY WIDTH	AXLE SHAFT KEY HEIGHT	MEDIUM SERIES ANTI-FRICTION BEARING BORE IN MM #	20° STUB TOOTH FORM STANDARD GEAR RATIO PINION TEETH	GEAR TEETH	PITCH	X+ FACE	GEAR CASE BELOW BASE
$ 2	25/32	3/4	12	12	24	2.7570	2 5/8	1 3/4		2 3/4	2 3/4	11.375	7/8	4 1/2		25	3 3/4	4 1/2			1/2	1/2	3/4	1/2	45	15 *	76 *	4 *	3 *	2 1/2
602	25/32	3/4	12	12	24	2.7570	2 5/8	1 3/4	1.953	2 3/4	3 1/4	11.375	7/8	4 1/2	1	25	3 3/4	4 1/2	1 3/16	2	1/2	1/2	3/4	1/2	50	15	76	4	3	2 1/2
603	29/32	7/8	13 1/2	13 1/2	27	3.1507	3 1/8	2	2.150	3 1/4	3 1/2	12.625	1	5 1/2	1 1/4	28	4 1/2	5	1 1/4	2 1/4	1/2	1/2	3/4	1/2	55	17	84	4	3 1/2	2 1/2
604	29/32	7/8	14 1/2	14 1/2	29	3.5445	3 1/2	2	2.545	3 1/4	3 1/2	13.375	1	5 1/2	1 1/4	30	5	5 1/2	1 1/4	2 1/4	1/2	1/2	3/4	1/2	65	18	89	4	3 1/2	2 3/4
606	1 1/32	1	15 1/2	15 1/2	31	3.9383	3 7/8	2 1/2	2.938	3 3/4	4	14.875	1 1/8	6 1/4	1 1/2	32	5	6	1 3/8	2 3/4	1/2	1/2	1	3/4	75	20	99	4	4	2 3/4
608	1 3/16	1 1/8	17 1/2	17 1/2	35	4.33[illegible]	4 5/16	3	3.332	4 1/4	5	16.833	1 1/8	7 1/4	2	36	5 1/8	6 1/2	1 1/2	3 1/2	3/4	1/2	1	3/4	85	17	84	3	4 1/2	3 1/4
610	1 3/16	1 1/8	18 3/4	18 3/4	37 1/2	4.7260	4 11/16	3 1/4	3.725	4 1/4	5 1/4	17.833	1 1/8	8	2 1/4	38 1/2	5 3/4	7	1 5/8	4	3/4	1/2	1	3/4	95	18	89	3	4 1/2	3
612	1 5/16	1 1/4	20 1/2	20 1/2	41	5.1197	5 1/16	3 5/8	4.119	4 3/4	5 5/8	19.166	1 1/4	8 3/4	2 1/2	42	6 1/4	8	1 3/4	4 1/4	3/4	1/2	1 1/4	7/8	105	19	96	3	5	3
614	1 5/16	1 1/2	23 1/4	23 1/4	46 1/2	5.9072	5 7/8	4 1/4	4.516	4 3/4	6 1/4	21.800	1 1/4	10	3	47 1/2	7 1/4	9	1 7/8	4 3/4	1	3/4	1 1/2	1	115°	18	91	2 1/2	5	4 1/8
616	1 9/16	1 1/2	26	26	52	6.6950	6 9/16	4 5/8	5.103	5 1/4	7	24.200	1 1/2	10	3 1/4	53	8 1/2	10	2	5 3/8	1 1/4	3/4	1 1/2	1	130	20	101	2 1/2	5 1/2	4 1/2
618	1 13/16	1 3/4	27 1/2	27 1/2	55	7.4822	7 3/8	5	5.500	5 3/4	7 1/2	26.750	1 1/2	10	3 1/2	56	8	11	1 9/16	5 3/4	1 1/4	1	1 1/2	1	140	18	89	2	6	5

NOTES (CONTINUED) -

* AISE FRAME 2, 5HP (60 MINUTE RATING) IS CARRIED OVER FROM PREVIOUS AISE MILL MOTOR STANDARD

° 14 1/2° TOOTH FORM MAY BE USED AS AN ALTERNATE STANDARD ON AISE FRAME 2.

Figure 1 — AISE Standardized D-C Mill Motor Dimensions.

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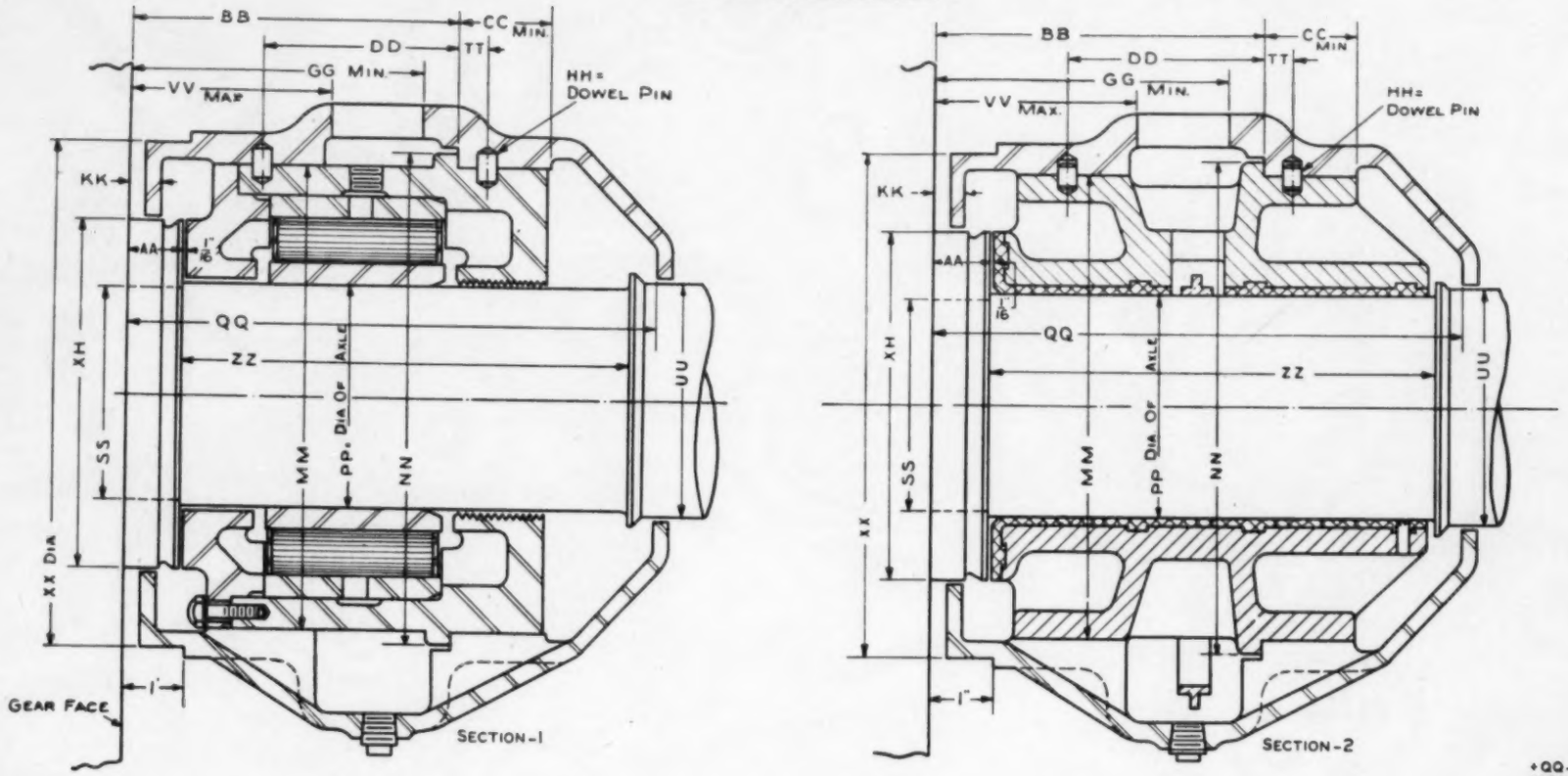


+QQ-MINIMUM DIMENSION (APPROX.)
▲MM-FOR SLEEVE AND ROLLER BEARINGS
*KK-MAXIMUM DIMENSION (APPROX.)
≠ZZ-IF OIL SLINGER IS USED
●OR EQUIVALENT

AISE MOTOR FRAME	SECT. NO.	AA	BB	CC	DD	GG	HH	KK *	MM ▲	NN	+.0000 -.0005 PP	QQ +	SS	TT	MAXIMUM UU	VV	XH	XX	ZZ	200 SERIES BEARINGS
‡ 2	1-2	7/8	4 5/8	1 1/8	2 1/2	4 3/8	3/8	1/2	5.937	6 7/16	2.7570	7 1/4	2 5/8	1/2	2 13/16	2 7/8	4 1/2	7 1/8	5 3/4	W-214H
602	1-2	7/8	4 5/8	1 1/8	2 1/2	4 3/8	3/8	1/2	5.937	6 7/16	2.7570	7 1/4	2 5/8	1/2	2 13/16	2 7/8	4 1/2	7 1/8	5 3/4	W-214H
603	1-2	7/8	5	1 3/8	2 7/8	4 1/2	3/8	1/2	6.500	7	3.1507	7 3/4	3 1/8	1/2	3 3/16	3	5	7 3/4	6 1/2	W-216H
604	1-2	1	5 3/8	1 1/2	3 1/8	4 7/8	3/8	1/2	7.312	7 3/4	3.5445	8 1/2	3 1/2	1/2	3 9/16	3 3/8	5 1/2	8 1/2	7 1/4	W-218H
606	1-2	1	5 7/8	1 3/4	3 1/2	5 1/8	3/8	1/2	8.125	8 5/8	3.9383	9 1/4	3 7/8	1/2	4	3 5/8	6	9 1/2	8	W-220H
608	1-2	1 1/8	6 3/8	2	3 7/8	5 1/2	1/2	9/16	9.125	9 5/8	4.3320	10 1/4	4 5/16	5/8	4 3/8	4	6 1/2	10 1/2	8 3/4	W-222H
610	1-2	1 1/8	6 7/8	2	4 1/2	5 7/8	1/2	9/16	9.750	10 1/4	4.7260	10 7/8	4 11/16	5/8	4 13/16	4 3/8	7	11 1/4	9 1/2	W-224H
612	1-2	1 1/4	7 1/2	2 1/4	4 7/8	6 1/4	1/2	9/16	10.375	10 7/8	5.1197	11 7/8	5 1/16	3/4	5 1/8	4 3/4	8	11 7/8	10 1/4	W-226H
614	1-2	1 1/4	8 1/2	2 1/2	5 3/4	7	1/2	9/16	12.000	12 5/8	5.9072	13 7/8	5 7/8	3/4	6	5 1/2	9	13 1/2	12 1/4	W-230H
616	1-2	1 3/8	9 3/8	2 3/4	6	8 5/8	5/8	5/8	13.625	14 3/8	6.6950	15 1/4	6 9/16	1 1/4	6 3/4	6 1/8	10	15 1/2	13 1/2	W-234H
618	1-2	1 7/16	10 1/2	3	6 1/4	9 1/8	5/8	11/16	14.750	15 1/2	7.4822	17 1/4	7 3/8	1 1/2	7 9/16	6 5/8	11	16 1/2	15 1/8	W-238H

NOTE:-
‡ AISE FRAME 2, 5HP (60 MINUTE RATING) IS CARRIED OVER FROM PREVIOUS AISE MILL MOTOR STANDARD

Figure 2 — AISE Standardized D-C Mill Motor Back Axle Details.

REPORT OF AISE D-C MILL MOTOR STANDARDIZATION COMMITTEE

BY F. O. SCHNURE, CHAIRMAN

. . . . the development of these new standards for mill motors keeps this standard of the Association of Iron and Steel Engineers in step with recent progress in motor design . . . .

▲ THE AISE d-c mill motor standard is the oldest and perhaps best known of the Association standards. It is a standard which has also found fairly extensive use outside the steel industry.

The initial work on this standard was started in the fall of 1925. After an open meeting attended by steel mill operators and manufacturer's representatives, the presidents of the American steel producing companies were contacted for approval and support. The approval was practically unanimous.

The committee to handle this standardization was formed early in 1926 with A. C. Cummins, as chairman. Mr. Cummins was active in this work until his death a few months ago, and now James Farrington and Carl Lange, who has just retired, are the only original committee members who are still active.

The standardization work on this motor was based on the fundamental principle that the work would be limited to standardization of ratings, and external dimensions. It was and is not the intention to hamper the designing engineer in establishing the electric and mechanical characteristics of the motor. The Association has never requested the manufacturers to develop or build any particular line of motors but have requested only that when they might be built, that such motors would be interchangeable as complete units regardless of the manufacturer. These principles should be kept in mind when reviewing the motor standardization work.

One other basic principle that the AISE has kept in mind in this work is that the standards should be in accord with the desires of the majority of the members. The original standard was based on a questionnaire circulated to the industry, and this practice plus contact through committee work and open meetings, as well as publication of all pertinent points in the *Iron and Steel Engineer* has informed the membership of what was being done, and also informed the committee of what the members required.

The work of this first committee was completed in 1926, and a standard set of ratings and mounting dimensions was adopted for 7 motors ranging from 7½ to 75 hp. These motors were of the split frame type and were adapted for use with either sleeve or anti-friction bearings and were commonly known as the long motor.

In 1928, the mill motor committee under the chairmanship of A. C. Cummins reviewed the 1926 standard and made some minor changes in a few of the dimensions.

In 1939, the mill motor committee was reformed with G. R. Carroll as chairman. The previous decade had seen many advances, as well as changes in operating requirements, and it was decided to review completely the mill motor program. The work of this committee ended in the following changes in the standards:

1. The standard d-c mill motor became the so-called short motor which was designed for use with anti-friction bearings only. The long frame motor became a modification of the standard motor.
2. The 5, 100, and 150 hp ratings were added to the original motor line.
3. Additional dimensions and details on ratings were added to the standard drawings.

This motor has been the standard up to the present.

During the past few years, developments in motor design, insulation and ventilation led one motor manufacturer to develop a new motor design which would take advantage of these developments. This motor was first introduced in May, 1946 by one of the manufacturers, when the mill motor committee and representatives of the steel plants were invited to the motor factory for an inspection of the mill motor.

The motor which was introduced is similar in outward design and appearance to the old motor, but is improved so that each rating could be made in the next smaller frame size. The mounting dimensions are the same for the old as for the new lines, and the motors are completely interchangeable, although brakes and couplings may require checking. The manufacturer then formally requested that the AISE standards be studied with a view of revision.

During the summer of 1946, the electrical men in the steel industry were contacted with a questionnaire to determine what they wanted in the new motor. The results of this questionnaire were reported by Frank Cramer at the 1946 Annual Convention. This questionnaire indicated that the present AISE standard dimensions for mill motors should remain unchanged; opinion was about equally divided as to the necessity of adding more sizes; it was conceded that all the present ratings were not necessary; it was not deemed advisable to increase the present 75 C rise, and the majority felt

Presented before AISE Annual Convention, Pittsburgh, Penna., September 23, 1947

that speeds should be held at the present standards for the same horsepower.

The mill motor committee was then reorganized this year with myself as chairman. The first meeting was held on February 17, 1947. At this meeting it was decided to:

1. Reduce mounting dimensions of AISE mill motors one frame size.
2. Since such rerating would eliminate the 5 hp size, after further study, it was decided to establish two motors in the present No. 2 frame, one motor being the old 5 hp motor and the other motor being the new 7½ hp motor. This decision was made because it was felt that because of the small number of orders in this size, the development costs of a new frame would make it uneconomical.
3. A new motor with a 60 minute rating of 200 hp was established for the No. 18 AISE frame.
4. The committee eliminated the 15 and 30 minute, and 5 hour, rms, fifty per cent time on ratings. This was done to eliminate confusion, or because of slight usage. The data can be determined from the motor characteristic curves.
5. The ratings to be used are the one hour, and 5 hour continuous rating.
6. It was decided to adopt the 600 series as the nomenclature for the new motor.

A sub-committee of manufacturer's representatives was formed to establish:

1. Necessary dimensional data for new standard.
2. Standardize on bearing sizes.
3. Standardize on gearing on pinions of back axle motors.
4. Standardize on shaft fillets.
5. Standardize on end nuts.
6. Standardize on relative position of leads.

This sub-committee consisted of:

1. Carl W. Lange, General Electric Company, Chairman.
2. C. B. Hathaway, Westinghouse Electric Corporation.
3. I. C. Smith, Crocker-Wheeler Electric Manufacturing Company.
4. C. F. Cobb, Allis-Chalmers Manufacturing Company.

The fourth member later resigned from the committee.

One subject which was discussed, but on which little was done, was the difficulty that occurred in mounting brakes because of variation in clearance dimensions between different manufacturers. With the new proposed motor design, it was felt that it would be desirable to standardize pertinent brake dimensions, so all brakes could be used on the same motor setting.

The details referred to the manufacturer's sub-committee were established through correspondence and meetings, and the following was recommended in a report submitted to the mill motor committee on June 19, 1947:

1. The final dimensional details.
2. A standardized series of bearings.
3. The 20 degree stub tooth was adopted for the gearing. (The increased strength of the 20 over the 14½ degree enabled the use of the same size pinion for the larger load).
4. The relative position of the external leads was standardized.
5. A standard shaft fillet of 7/16 in. radius was adopted for all shaft sizes.
6. Standard dimensions across the flats on nuts, and threaded ends of shafts.
7. Standard bell mouthing of pinions at large end of the taper bore.
8. Counterbore in couplings for wrench clearance.

It was not found feasible to standardize on brake lugs, or rectangular openings for force-ventilation.

Many of the items listed above are now standardized for the first time.

The standard was now approved by the mill motor committee by a vote of 14 to 1. The standard was then submitted to the standardization committee who approved it by a vote of 12 to 2, with 2 not voting. On September 22, 1947, the Board of Directors of the AISE adopted the new standard.

D-C MILL MOTOR STANDARDS

Few criticisms or comments were received on the changes adopted in the new standard. The following summarizes the comments received:

One committee member stated, "The dimensions are approved except that the center line of the back axle should be on the same center line as that of the armature shaft." The new standard was made the same as the old standard on these dimensions.

Another committee member wished the maximum height of each frame to be shown and this has been done.

There has been some comment on the use of a 323 bearing in the 614 frame motor since it is not a standard bearing. However, the committee does not feel that this item will give concern as one manufacturer is now making this bearing. Also, one of the motor manufacturers can use only this bearing, and another prefers to do so.

Another committee member requested that on the drawing, a table be given which shows, "Ventilation required for each motor size to make continuous rating with ventilation equal to the 60 minute enclosed rating." This has been done.

One of the men who voted against the standard did so because he felt that the improvements in design were insufficient to warrant adopting a new standard.

Another person who voted against the standard approved the work of the committee but felt that we should not adopt the standard so quickly but should wait until field and operating experience was available from users. In the event he was outvoted, he felt the standard should be adopted as a tentative standard for a year subject to review at the end of the period. At the end of the year if the standard were adopted, it should be a final standard, and present short motor should be used for replacement only.

DISCUSSION

PRESENTED BY

F. A. COMPTON, JR., Engineer D-c Armored Motor, Engineering Division, General Electric Company, Erie, Pennsylvania

C. B. HATHAWAY, Manager D-c Motor Division, Westinghouse Electric Corporation, Buffalo, New York

J. W. DEIMLER, Electrical Engineer, Alan Wood Steel Company, Conshohocken, Pennsylvania

F. A. Compton: Mr. Schnure has just presented a very complete report on d-c mill motor standards and there is very little that I can add to this. Mr. C. W. Lange, who was chairman of the sub-committee composed of mill motor manufacturers, retired from active service with the General Electric Company, on August 1 and I have been carrying on his work since his retirement.

I believe that the adoption of additional dimensions in the new 600 standards, such as maximum overall height, air requirements, lead location, shaft nut and threads, shaft shoulder and fillet and pinion relief is a step in the right direction as these dimensions affect not only the motor manufacturer but the application engineers, machinery manufacturers, manufacturers of gears, couplings and brakes, as well as the ultimate user. I would like to comment briefly on the aspects of these additions to the 600 standards.

1. *Maximum overall motor height* — This requirement assures the user that all motors will come within that dimension regardless of manufacturer.

2. *Air requirements* — The 1940 standards carried a statement to the effect that a continuous rating equal to the one hour enclosed rating could be obtained when the motors were ventilated with the proper amount of air. It was suggested by a member of the mill motor committee that the actual air requirements be included as part of the standards and this has now been done. Table I includes the cfm air, and static pressure required to force this air through the motor for each frame size.

3. *Relative location of leads* — Due to differences in design and manufacturing practices, it was not considered feasible to standardize on the exact lead location. However, the relative location of the leads with respect to each other was agreed upon and is included in the new standards in Figure 1.

4. *Shaft nuts and threads* — The ZF and XE dimensions of Figure 1 cover the distance across the flats of the pinion nut and the shaft threads. Pinion nut wrenches will now be the same for all standardized motors regardless of manufacturer. Standardization of shaft threads means that the same lifting devices can be used on all armatures of a given frame size, as well as pullers and other tools.

5. *Shaft shoulder and fillet* — The UA dimension of Figure 1 is the diameter of the shaft where it enters the bearing enclosure, and the shaft fillet is the fillet between the UA diameter and the U diameter of the taper fit. In the old short frame motors of the 1940 standards, the UA diameter was the same as the U taper fit diameter in most cases. With the increase in bearing size for each frame the UA diameter and 1/16 in. fillet represent the largest shaft that can be obtained, and one in which the shaft stresses and deflection will be comparable to those of the 1940 standards.

6. *Pinion relief, radius or chamfer* — Although this is shown in Figure 1 as applying to pinions, it is also applicable to couplings and brake wheels. Although the radius relief commonly referred to as bell mouthing the large end of the pinion bore has some theoretical advantages over the chamfer, either type of relief tends to insure a better pinion fit for two reasons:

a. In handling of pinions, brake wheels or couplings, it is very easy to nick the edge of the bore at the large end which generally upsets metal into the bore, giving a high spot and preventing proper fit between bore and shaft.

b. The relief also gives added insurance toward preventing the pinion from riding on the shaft fillet in case the pinion bore is on the large side. A further improvement in assuring a better pinion fit is to make the nominal bore of the pinion a few thousandths of an inch undersize to allow for pinion expansion during assembly. Although pinion keys are provided they should not be depended upon to transmit the torque on heavy duty reversing service. The keys should be considered only as an auxiliary means to prevent pinion slipping. All pinions, brake wheels and couplings should be mounted tight enough to transmit the torque by virtue of friction between the bore and the shaft. It is very easy to control accurately the interference fit between pinion and shaft by hot mounting the pinions.

It has been interesting to note the enthusiasm shown in the acceptance of the new 600 motors by the steel companies as well as by other users of the standardized motor. This acceptance is evidenced by our orders received records for this year. In March approximately 30 per cent of the orders received by our company this year were for 600 series motors and 70 per cent for the short frame 1940 standard motors. By August this percentage had increased to 40 per cent for the 600 series motor.

C. B. Hathaway: I should like to emphasize what users will get in the new line of mill motors.

1. Rating for rating the armatures in the new motors are as large and in some cases larger than they were in the old motor.
2. There are just as many pounds of copper and magnetic iron in the new motors and in some cases more than in the present line. The significance of these two facts is that the inherent thermal capacity of the new motors is equal to and in some cases greater than in the old ones.
3. In redesigning the armatures betterp ropertion of diameter to length of core was used to keep the moment of inertia or WR^2 low. This is beneficial in reducing and stored energy whenever frequent starts, stops and reversals are necessary.
4. The use of silicone varnish in the armature coils gives them added protection against high temperature.

   The use of silicone varnish in the armature coils gives them added protection against high temperature. It is recognized that the armature is the heart of any d-c motor. It was not necessary to reduce its size in the new design. In some cases it is larger than that in the old line for the same rating. The new armature is also a better design than the old.
5. The use of four commutating poles increases the range of commutation with a resulting reduction in maintenance of the commutator. The use of split brushes in the larger sizes is also an aid in this direction.
6. The reduction in size makes possible more compact assembling of the machinery. The tests we have taken so far for the 5-hour continuous ratings have been very gratifying. Rating for rating, there has been a greater margin under the limit in the new motors than in the old.

The new motors, essentially, have armatures that are equivalent to those in the old, rating for rating. That was accomplished by using the greater length that is available in the motor when it is designed only for roller bearings. That provides more space for core length. Economizing on the field space by using four commutating poles provides more space in the field, which permits a larger armature in the same overall space.

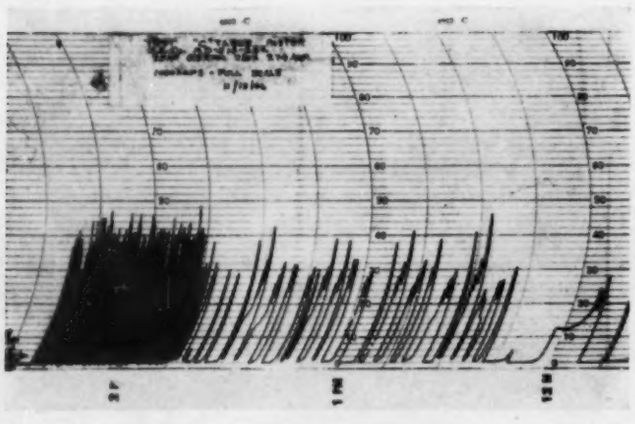
Machines having 4 main poles may have 2 or 4 commutating poles. The coil for the 4 commutating pole arrangement will have about 80 per cent of the turns on it that is required for the coil where only 2 commutating poles are used. The economizing of the field space permits an armature of larger diameter. Thus space for an armature of larger diameter is provided in this way and as mentioned before the increased length of core is afforded by designing the motor for roller bearings only. The old line was designed to accommodate either sleeve or roller bearings.

Users of the new motors can be reassured that they are getting a better motor than they have ever had before. In addition to the points enumerated, there are other refinements of details brought about by experience gained during the last twenty years. Furthermore, the motors have been brought up to date by the most modern design known to the art. The new motors should give better performance than ever experienced before and will be a credit to the industry.

J. W. Deimler: A new MD 614, 100 hp mill type d-c motor was placed in service on the discharge table of our blooming mill in March 1947. This motor replaced an MD 414, 75 hp motor which had been in service approximately two years. The operating cycle of this table is quite severe and is a good test for any drive unit.

Although the smaller motor never failed to give good service, it was evident from the first day of operation that this machine was overloaded and approaching the safe limit of temperature rating. The chart, as shown by Figure I, represents the armature and series field current taken by this motor under typical load conditions. It will be noted that peak currents were in the range of 400 to 430 amperes at 240 volts. Average reversals were 10 per minute. Figuring about 90 per cent for overall efficiency, this machine had an output

Figure 1 — The current temperature curve shows that the 414 motor was commonly loaded above its rated load.



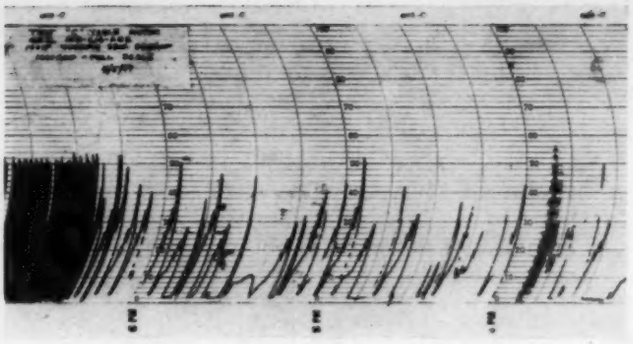


Figure 2 — The new 614 motor is not overloaded as much as the previous 414 motor.

of about 90 hp. Temperature readings taken on the outside of the motor frame at the pole pieces showed a temperature rise of about 52 C during this particular test.

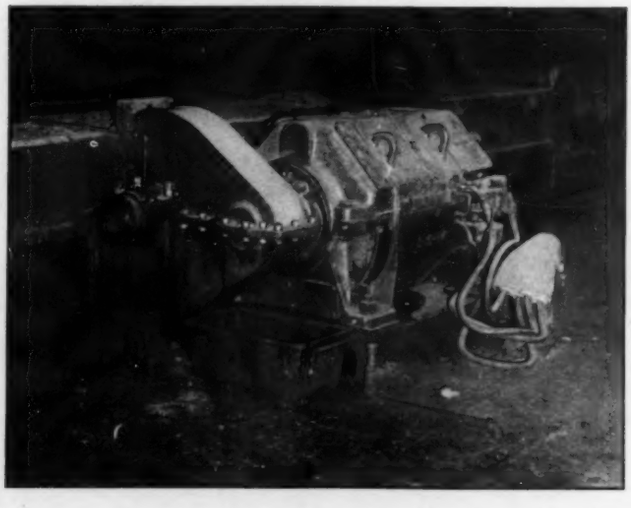
Figure 2 is a graphic chart of the armature and series field current for the MD 614 motor. It will be noted that peak currents range from 460 to 520 amperes at 240 volts but the average load is approximately the same as that of the smaller motor. Temperature readings taken during an eight hour operating period following a week-end shutdown indicated a maximum temperature rise of 40.1 C. This reading was also taken on the outside of the frame at the pole piece. A temperature reading of one of the series field coils was also taken in this test and the highest reading obtained was 82.2 C.

A photograph of the actual installation of this motor is shown in Figure 3. This motor was set in identically the same location as that occupied by the 75 hp motor. It was not necessary to make any changes whatsoever in the mounting bolts, pinions, cable connections, or other physical or mechanical parts.

During the past five months, the observed performance of this motor has been entirely satisfactory. Commutation is excellent even during the occurrence of the high current peaks at reversal.

The tests which we made, while simple in nature, are indicative of results obtained by a particular application of the higher rated motor in the same frame size.

Figure 3 — Replacing the old motor with the new motor, even though the rating of the latter was one-third greater, gave no installation problems.



Selection of Gear Ratios

FOR CRANE BRIDGE DRIVES

. . . unless the proper gear ratio is selected for a bridge drive, neither the required bridge speed nor the best acceleration characteristics will be attained . . . .

By JOHN L. SKEEHAN
Development Engineer
Treadwell Construction Company
Midland, Pennsylvania

▲ RECENT articles on gear ratios on bridge drives of traveling cranes indicate the interest in the subject and demonstrate that the problem of designing bridge drives has not been satisfactorily solved. The following article describes an approach which, I believe, is original. The single experiment made to test the method was made by others and reported to the writer. If any suggestions embodied in this article are utilized to make electric cranes travel at more nearly the calculated speed, the article will have served its purpose.

Several years ago, at a meeting of the Association of Iron and Steel Engineers, there was a symposium on crane bridge drives participated in by representatives of several prominent crane builders and manufacturers of electric motors and control. During the discussion, a representative of one crane builder illustrated the difficulty in controlling bridge speeds by citing an instance where a series wound direct current bridge motor, calculated on the basis of quick acceleration, gave a travel speed, in a relatively long run, nearly 100 per cent higher than had been anticipated and desired.

At one point a suggestion was made that the gear ratio between motor and track wheel might be an important factor, but the idea was not enlarged upon or developed at that time. About three years previous to the symposium, a problem of this nature was presented to the writer. The manager of a plant distant from the central engineering office of a large corporation requested that steps be taken to increase the running speed of a yard crane built by the company for itself in 1918.

The following are the data for this crane:

Capacity . . . . . 10 tons
Span . . . . . 90 feet
Weight, loaded . . . . . about 100,000 pounds
Track wheels, 4; 2 driven — 24 in. diameter
Axles . . . . . 4½ in. diameter
Motor . . . . . G. E. C01809
1915 ratings:
25 hp — 550 rpm — 30 minutes, 55 C rise
35 hp — 450 rpm — 15 minutes
Motor reduction gears . . . . . 19 — 97
Axle reduction gears . . . . . 23 — 62
Gear on axle, 62 tooth, 2½ diametral pitch, 24.8 in. pitch diameter
Total reduction . . . . . 12.4 to 1
Calculated speed, shown on the drawing, based on 550 rpm of motor with no attention to torque — speed curves was 276 rpm.

The manager, assuming that the speed of the crane was in agreement with the figures on the drawing, asked that the speed be increased by 100 fpm to 375 fpm.

A re-calculation of speed was made, based on torque — speed curves which presumably applied to this motor. Assuming a coefficient of axle friction of 7 per cent; efficiency, motor to axle, 90 per cent; taking no note of rolling on flange friction, the turning moment required at axle is:

$$100{,}000 \times 0.07 \times \frac{4\frac{1}{2}}{24} = 1310 \text{ lb ft}$$

$$\text{Torque moment on motor} = \frac{1310}{12.4 \times 0.90} = 118 \text{ lb ft}$$

Bridge speed should be $\frac{705}{12.4} \times 2 \times \pi = 357$ fpm after acceleration.

An actual check was made by taking the time to traverse a measured distance after the loaded crane had been brought up to full speed.
Running against wind, test gave 120 ft in 21 sec = 343 fpm.
Running with wind, test gave 120 ft in 18.2 sec = 395 fpm.
This is an average of . . . . . 395 fpm, which is about 3 per cent above the calculated speed.

At the same time ammeter readings were taken:
Starting . . . . . 175 amp
Running . . . . . 60 amp

Voltage.....230-240

From the curve, 60 amp, 230 volts, corresponds to 120 ft lb torque, 16.5 hp, 730 rpm. At 730 motor rpm, travel speed should be:

$$\frac{730 \times 2 \times \pi}{12.4} = 366 \text{ fpm}$$

This example works out very close to expectations and leads to a rational method for the solution of this problem.

In this case we had a motor with given characteristics, a crane of a given weight and a given gear ratio from which to calculate the speed at which we might expect the crane to travel. If the method of calculation and the assumptions as to frictions, etc., indicate a speed closely approximating that attained under test, we may be justified in using a reversal of the method in seeking the gear ratio which should produce a given travel speed.

This ideal gear ratio should lie at the intersection of two curves, see Figure 1. Curve No. 1 is the available motor torque at various rpm of the motor, and curve No. 2 is the torque imposed on the motor, through various gear ratios, in overcoming resistance to movement of the crane.

As all of our conditions in this problem were fixed, there was no need to draw curves in the case previously cited.

DESIGN COMPUTATION ONE

In 1941 the following problem arose in a bridge drive design:

Capacity.....25 and 10 tons
Span.....76 ft
Weight of crane and trolley.....140,000 lb
Load.....50,000 lb
Total weight.....190,000 lb
Track wheels 4; 2 driven.....24 in. diameter
Axles.....5 in.
Desired travel speed.....300 fpm

The bridge motor on a similar crane built in 1918 was:

G. E., CO-1810, 230 volts, d-c, series wound, 35 hp, 500 rpm, 30 minutes, 55C rating.

The equivalent frame at time new crane was being designed was the CO-1830 with low speed ratings:

50 hp — 30 min — 525 rpm.....500 ft lb torque
65 hp — 15 min — 450 rpm.....760 ft lb torque

Using a coefficient of running axle friction of 7 per cent, and an efficiency of 90 per cent motor to axle, the same as is assumed in the 1942 AISE crane specifications, the horsepower required to keep the crane running at 300 fpm after acceleration:

$$\text{Hp} = 190{,}000 \times \frac{7}{100} \times \frac{5}{24} \times 300 \times \frac{1}{0.9 \times 33{,}000} = 28 \text{ hp}$$

The gear reduction may be so proportioned that a 50 hp, 525 rpm motor will run at:

1. Higher speed.
2. Lower torque.
3. Lower horsepower than rating, with crane traveling at 300 fpm. The moment required to turn the 5 in. diam axles under a total load of 190,000 lb, 7 per cent friction, is:

$$190{,}000 \times \frac{2\frac{1}{2}}{12} \times \frac{7}{100} = 2770 \text{ ft lb}$$

The torque required at the motor, 90 per cent efficiency motor to axle is:

$$\frac{2770}{\text{Gear ratio} \times 0.90} = \frac{3080 \text{ ft lb}}{\text{Gear ratio}}$$

For the purpose of equating the *available* motor torque at various rpm of motor, against the motor torque *required* to deliver 3080 lb ft torque to the axle through *various gear reductions* to attain a crane speed of 300 fpm, Table I has been prepared.

TABLE I

Rpm of motor	Corresponding hp from rating curves	R* Total gear reduction	Motor torque—pound ft: Required $\frac{3080}{R}$	Motor torque—pound ft: Available at this rpm of motor
450	65 hp (15 min)	9.43	328	760
475		9.95	310	650
500		10.48	294	560
525	50 hp (30 min)	11.00	280	500
550		11.52	267	435
575	45 hp (1 hour)	12.05	255	390
600		12.58	245	350
625		13.10	235	305
650		13.60	226	275
675		14.14	218	245
700		14.68	210	220
725		15.20	202	200
750		15.70	196	180
775		16.25	189	165
800	24 hp (cont.)	16.75	184	160

*R is the total gear ratio, motor to 24 in. diam track wheel, to travel the crane at 300 fpm at the corresponding motor rpm on same line. Note that at the 725 rpm — 15.20 reduction, the required torque, 202 ft lb very nearly equals the available torque of 200 ft lb. See curve — Figure 1.

The *available* motor torque is taken from rating curves in 25 rpm intervals between 450 and 800 rpm. This curve, together with the curve of *required* motor torque, is shown in Figure 1.

It will be observed that the torque curves intersect at a motor speed of about 725 rpm, which requires a speed reduction of 15.2 to 1 to give a travel speed of 300 fpm.

It may therefore be reasonable to expect that after the acceleration period is passed, this motor should settle at 725 rpm and the crane should travel at 300 fpm.

Parenthetically, it might be noted that if the coefficient of friction were 10 per cent instead of 7 per cent, a 43 per cent increase, the expected speed with 15.2 to 1 reduction would drop to about 265 fpm or 12 per cent low.

Acceleration — Under NEMA Standard Resistor Classification, ... "the average accelerating current will not exceed 125 per cent of the full load value." As the motor torque, within reasonable ranges, approximately parallels the current input, we may assume that the motor will exert an average torque of 125 per cent

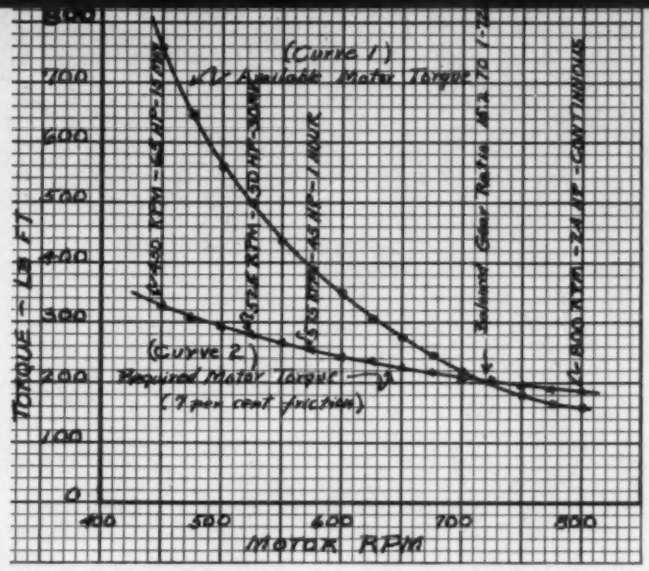


Figure 1 — The point at which the curve of available torque crosses the curve of required motor torque sets the final balancing speed of the motor.

of 500 ft lb or 625 ft lb during its period of acceleration.

625 ft lb available during acceleration,
−200 ft lb required to keep crane in motion against friction, and 425 ft lb is available at motor for acceleration.

This 425 ft lb is transmitted to a wheel of one foot radius, through a gear reduction of 15.2 to 1, and will produce an accelerating force of 425 × 15.2 = 6450 lb.

Kinetic energy of 190,000 lb at 300 fpm or 5 ft per sec with 32 for the value of g

$$= \frac{190{,}000 \times 5^2}{64} = \qquad 74{,}200 \text{ ft lb}$$

WR^2 of rotating parts = roughly 72, broken down into motor = 52.4, brake wheel = 17.5, gearing = 2.

Kinetic energy of rotating parts = $0.0001705\ WR^2\ (\text{rpm})^2 = 0.0001705 \times 72 \times 725^2 =$ 6,400 ft lb

Total kinetic energy imparted during acceleration = 80,600 ft lb

80,600 ft lb ÷ 6450 lb = 12.5 ft required to attain 300 rpm (5 fps)

$\frac{12.5 \times 2}{5} = 5.0$ seconds required to attain 5 fps

This gives: $\frac{5 \text{ fps}}{5 \text{ sec}} = 1 \text{ ft per sec}^2 = \text{acceleration}$

$\frac{100 \times 1}{32} = 3.125$ lb acceleration force per 100 lb of crane weight to be moved.

No opportunity was ever afforded to make a test of this crane's performance. The acceleration computations are approximate, as the actual torque available for acceleration will be less than the 125 per cent current torque when the bridge motor goes off the resistor.

DESIGN COMPUTATION TWO

AISE — SLEEVE BEARING AXLES

The AISE Electric Overhead Traveling Crane Specifications, section 43, Motors, paragraph 3-b states:

"The hp of the bridge drive motor shall be computed as follows:

$$\text{Hp} = \frac{2 \times W \times d \times 0.07 \times V}{33{,}000 \times 0.9 \times 0.9 \times D.} \quad \text{(For sleeve bearings)}$$

Where W = Total weight of crane plus rated load, pounds.
d = Diam of axle at journal, inches.
V = Specified bridge speed, fpm.
D = Track wheel diam, inches.
0.07 = Coefficient of friction, sleeve bearing.

The two factors 0.9 are respectively:

1. The 90 per cent factor introduced by the use of a specified speed of 90 per cent of ultimate bridge speed.
2. A 90 per cent gearing efficiency factor.

"In determining gear ratio for bridge drive with sleeve bearing axles, full load motor speed should be used, except with long runways, where traveling is long enough to build up excess speed, in which case a motor speed corresponding to a horsepower output lower than full rating may be desirable." (No suggestion is made as to what this "desirable" speed may be or how it may be figured.)

For the crane conditions specified in the design example previously in this article:

$$\text{Hp} = \frac{2 \times 190{,}000 \times 5 \times 0.07 \times 300}{33{,}000 \times 0.9 \times 0.9 \times 24} = 62\tfrac{1}{2} \text{ hp}$$

We will use a 65 hp motor, the nearest to the 62½ hp required.

The CO 1830 frame, high speed motor has ratings:
65 hp — 30 min — 700 rpm — 485 ft lb torque
85 hp — 15 min — 650 rpm — 685 ft lb torque

The motor torque required to rotate the 5 in. axles under total load of 190,000 lb, including the 90 per cent efficiency, motor to axle, and 7 per cent axle friction is as computed previously:

$$\frac{3080 \text{ lb ft}}{\text{Gear ratio}}$$

24 in. wheel traveling at 300 fpm must rotate 48 rpm. Gear reduction based on "full load motor speed" of crane specification = 700 ÷ 48 = 14.57 to 1, to get 300 fpm.

With this gear reduction, the tractive torque required to move the crane is:

$$\frac{3080}{14.57} = 211 \text{ ft lb torque}$$

With controller full on, and 230 volts, motor should speed up to 925 rpm according to motor rating curves before motor torque becomes less than tractive torque.

$\frac{925}{14.7} \times 2\pi = 400$ fpm, which is more than $\frac{300}{0.9}$ the design ultimate bridge speed.

Acceleration — Assuming 125 per cent of full rated torque during period on controller, this equals:

125 × 485 lb ft = 607 lb ft
607 lb ft available at motor while on controller,
−211 lb ft required to keep crane in motion against [friction
396 lb ft is available at motor for acceleration.

396 ft lb transmitted to a 1 foot radius track wheel

through a gear reduction of 14.57 to 1, will provide an accelerating force of:

$396 \times 14.57 = 5750$ lb

Kinetic energy of 190,000 lb at 300 fpm = 74,200 ft lb

Kinetic energy of motor, brake, etc. at 709 rpm = 6,000 ft lb

Total kinetic energy = 80,200 ft lb

80,200 ft lb ÷ 5750 ft lb = 13.9 feet to attain 300 fpm

$$\frac{13.9 \times 2}{5} = 5.58 \text{ sec to attain 5 fps}$$

$$\frac{5 \text{ fps}}{5.58 \text{ sec}} = 0.9 \text{ ft per sec}^2 = \text{acceleration}$$

$$\frac{100 \times 0.9}{32} = 2.81 \text{ lb acceleration force per 100 lb crane [weight}$$

It will require $\frac{(400)^2}{(300)} \times 13.9 = 24.9$ ft to attain 400 fpm,

and $\frac{(400)}{(300)} \times 5.58 \text{ sec} = 7.47$ sec to get up to 400 fpm

neglecting approximation that torque available in acceleration cycle is less than 125 per cent after motor goes off resistor.

DESIGN COMPUTATION THREE

The CO 1830 motor, 65 hp — 700 rpm — 30 min rating may be used more advantageously if the gear reduction is proportioned so that the available motor torque at the motor speed required to give the "ultimate bridge speed" of say 300 ÷ 0.9 = 333 fpm, will balance the torque required to keep the crane running against the frictional resistance.

Better acceleration will also be attained.

Table II and Figure 2 have been prepared to determine the gear reduction necessary to produce the $\frac{3080 \text{ ft lb}}{\text{gear ratio}}$ torque and 333 fpm crane speed.

TABLE II

Rpm of motor	Corresponding hp from rating curves	R Total gear reduction	Motor torque—pound ft: Required $\frac{3080}{R}$	Motor torque—pound ft: Available at this rpm of motor
650	85 hp (15 min)	12.25	251	685
700	65 hp (30 min)	13.20	233	485
750		14.15	218	372
800		15.10	204	313
850	47 hp (1 hour)	16.00	192	267
900		17.00	181	215
925		17.45	176	208
950		17.90	171	191
975		18.30	167	180
1000		18.90	163	170
1025		19.40	159	160
1050	30 hp (2 hour)	19.80	156	150

Values correspond to curve in Figure 2.

$$\frac{333}{2\pi} = 53 \text{ rpm of track wheel}$$

Acceleration — It will be observed, from Table II that the required motor torque, 159 ft lb, with gear reduction of 19.5 to 1, nearly coincides with the available motor torque, 160 ft lb, at the motor speed of 1025 rpm. At this speed of motor, and with a gear reduction of about 20 to 1, the crane, after acceleration period, should run very closely to 333 fpm.

Assuming 125 per cent of 485 ft lb or 607 ft lb available motor torque during acceleration

607 ft lb available motor torque,

—160 ft lb to overcome frictional resistance.

and 447 ft lb is available at motor for acceleration.

This 447 ft lb, transmitted to a 1 foot radius track wheel through a gear reduction of say 20 to 1, will produce an acceleration force on crane of

$447 \times 20 =$ ..... 8,940 lb

Kinetic energy of 190,000 lb at 333 fpm (5.55 fps) $= \frac{190{,}000 \times 5.55^2}{64} =$ 92,000 ft lb

Kinetic energy of motor, etc = $0.0001705 \times WR^2 \times (\text{rpm})^2 = 0.0001705 \times 72 \times 1025^2 =$ 12,600 ft lb

Total Kinetic energy 104,600 ft lb

104,600 ft lb ÷ 8940 lb = 11.7 feet to attain 333 fpm.

$$\frac{11.7 \times 2}{5.55} = 4.2 \text{ sec to attain 5.55 fps}$$

$$\frac{5.55 \text{ fps}}{4.2 \text{ sec}} = 1.32 \text{ feet per sec}^2 = \text{acceleration}$$

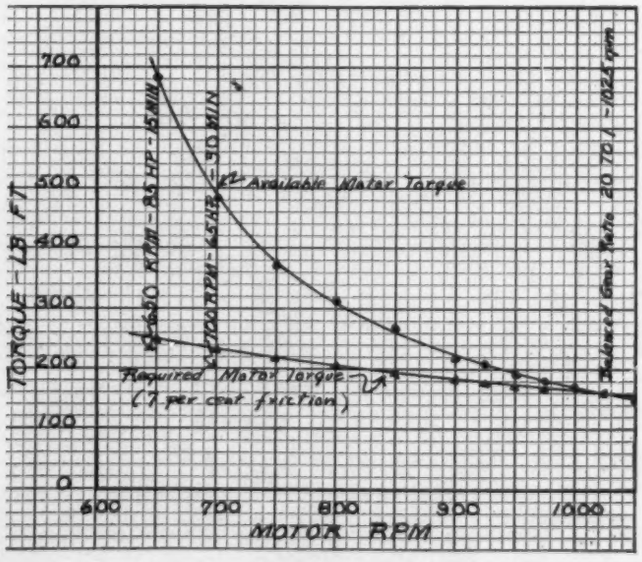
$$\frac{100 \times 1.32}{32} = 4.14 \text{ lb accelerating force per 100 lb weight}$$

on basis of same assumption as previous examples.

DESIGN COMPUTATION FOUR
AISE — ROLLER BEARING AXLES

The AISE Electric Overhead Traveling Crane Speci-

Figure 2 — This crane takes a gear ratio of 20-1 if the design speed is not to be exceeded.



fications, paragraph 3, section 43 states:

"The horsepower of the bridge drive motor shall be computed as follows:

(a) With Roller Bearings:

$$Hp = \frac{3 \times W \times V \times 15}{33{,}000 \times 0.9}$$

Where W = Total weight of crane plus lifted load, tons.
V = Specified bridge speed, fpm.
15 = Pounds of draw bar pull per ton of weight (includes gear and bearing friction based on 90 per cent efficiency).
0.9 = A factor introduced by the use of a specified speed of 90 per cent of ultimate bridge speed.

"In determining gear ratio for bridge drive with series wound d-c motors and roller bearing axles, use a motor speed corresponding to a horsepower output of ⅓ the full load horsepower as determined above."

Horsepower of bridge motor for crane used in design example $= \frac{3 \times 95 \times 300 \times 15}{33{,}000 \times 0.9} = 43$ hp

Selecting a motor with a rating nearest to 43 hp, we will assume a CO 1830, 50 hp, 525 rpm, 30 minute rating. At ⅓ of 43 hp or 14 hp, this motor will rotate about 1050 rpm.

The corresponding torque = 72 lb ft.

At $\frac{300}{0.90}$ or 333 fpm, a 24 in. track wheel must rotate

$333 \div 2\pi = 53$ rpm.

The required gear reduction will be

$1050 \div 53 = 19.8$ to 1

The torque exerted on the track wheel axle, disregarding efficiency which is taken care of in the formula (15 lb draw bar pull per ton) will be:

72 lb × 19.8 = 1425 ft lb available at track wheel.

15 lb per ton × 95 tons × 1 foot radius track wheel = 1425 lb ft required to overcome resistance.

The 1425 lb ft available at design speed balances the 1425 lb ft required.

Acceleration — Assuming 125 per cent of full torque of CO 1830 motor 50 hp, 525 rpm, as available during acceleration:

125 per cent × 500 lb ft
= 625 lb ft available at motor
— 72 lb ft required to overcome friction
and 553 lb ft is available for acceleration.

553 × 18.4 = 10,200 lb at the rim of a 1 foot radius track wheel available for acceleration.

Kinetic energy of 190,000 lb @ 333 rpm = 92,000 ft lb
Kinetic energy of motor, brake, wheel, etc., at 1050 rpm = 0.0001705 × 72 × 1050 = 13,300 ft lb

Total kinetic energy = 105,300 ft lb

105,300 ft lb ÷ 10,200 lb = 10.3 feet to attain 333 fpm

$\frac{10.3 \times 2}{5.55} = 3.70$ sec to attain 5.55 fps

$\frac{5.55}{3.70} = 1.50$ feet per sec² = acceleration

$\frac{100 \times 1.50}{32} = 4.7$ lb acceleration force per 100 lb

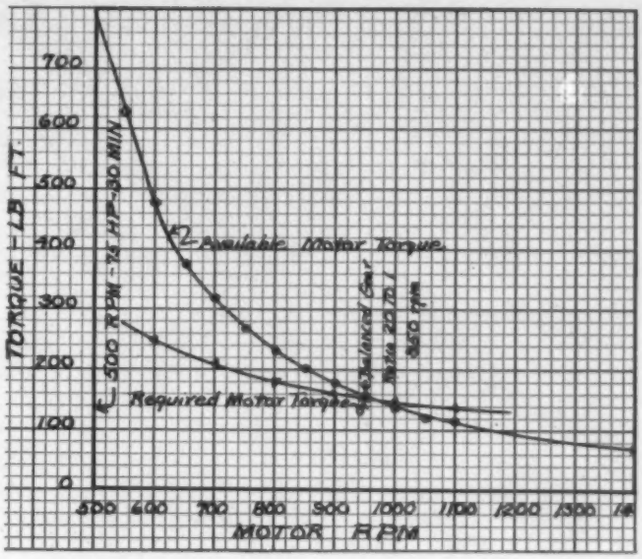


Figure 3 — The gear ratio which gives the balanced design speed will also give the fastest acceleration.

Acceleration computations are based on same assumptions as previous examples.

Where a bridge motor is selected on a 30 minute horsepower rating, according to the AISE formula for sleeve bearings, and the gear reduction is proportioned to give an approximate balance between *available* motor torque and *required* motor torque, the actual crane speed, after acceleration, should closely approximate the calculated speed on a long run.

The rated motor horsepower (30 min, 55C) is more than that required to keep the crane moving at the calculated speed. Therefore, the motor speeds up beyond its full load rating; and the horsepower and torque will decrease to the natural balance.

Contrary to the AISE specifications, which state that for sleeve bearing cranes that the gear ratio should be based on full load motor speed, the examples indicate that the gear ratio should be increased to the point where the *available* motor torque approximates the *required* motor torque. Somewhat better acceleration is attained as is shown in the resume, and the calculated speed over long runs will be more closely approximated.

DESIGN COMPUTATION FIVE

At the symposium referred to earlier in this article, the electric superintendent of one large corporation stated that bridge motors should be selected to take into consideration every factor of loading of the motor, determine the frame size meeting these requirements, and then select the next larger frame motor.

An analysis of this method of selection will be made on the basis of the design example crane.

This will give a CO 1831 motor (one size larger than CO 1830)

75 hp — 30 min — 500 rpm — 790 ft lb torque
100 hp — 15 min — 450 rpm — 1165 ft lb torque

On Figure 3 the curve of available motor torque crosses the curve of required motor torque at 950 rpm and 155 ft lb.

The gear ratio at 950 rpm of motor, 300 fpm on 24 in. track wheels is $\frac{950 \times 2\pi}{300} = 20$ to 1 approximately.

$$\frac{3080 \text{ ft lb at axle}}{20 \text{ (gear ratio)}} = 154 \text{ lb ft required at motor to keep}$$

crane moving at 300 fpm after acceleration. The crane after accelerating, should continue to run at 300 fpm.

Acceleration — Assuming 125 per cent of full motor torque of 790 ft lb, 30 minute rating, or say 1000 ft lb average available motor torque during accelerating period, and 155 ft lb required to overcome frictional resistance, there will be 845 ft lb motor torque available during acceleration period.

845 ft lb × 20 (the gear ratio) = 16,900 lb at the rim of a 1 foot radius track wheel available for acceleration.

Kinetic energy of 190,000 lb crane at 300 fpm =	74,200 ft lb
Kinetic energy of motor, brake, wheel, etc, at 950 rpm = $0.0001705 \times 130 \times 950^2$ =	19,500 ft lb
Total kinetic energy of moving parts =	93,700 ft lb

$$\frac{93{,}700 \text{ ft lb}}{16{,}900 \text{ lb}} = 5.55 \text{ feet to accelerate to 300 fpm}$$

$$\frac{5.55 \times 2}{5} = 2.22 \text{ sec to accelerate to 5 fps}$$

$$\frac{5 \text{ fps}}{2.22 \text{ sec}} = 2.25 \text{ feet per sec}^2 = \text{acceleration}$$

$$\frac{2.25 \times 100}{32} = 7.1 \text{ lb force per 100 lb moved}$$

A coefficient of friction of 2 × 7.1 or 14 per cent, wheel to rail, will just prevent wheels from spinning if half the wheels are driven.

SUMMARY

1. *Design computation one*

CO 1830 Motor — 50 hp — 30 min — 525 rpm
Gear reduction 15.2 to 1 ..... Balanced
Desired crane speed, after acceleration ..... 300 fpm
Expected crane speed, after acceleration ..... 300 fpm
Acceleration — Space to attain 300 fpm ..... 12.5 ft
Acceleration — Time to attain 300 fpm ..... 5.0 sec
Acceleration — Rate (5 fps in 5 sec) ..... 1 fps²
Acceleration — Force per 100 lb ..... 3.125 lb

2. *Design computation two*

AISE Specifications — Sleeve Bearing Axles
CO 1830 Motor — 65 hp — 30 min — 700 rpm
Gear reduction 14.57 to 1, based on "full load motor speed"
Desired crane speed, after acceleration ..... 333 fpm
Expected crane speed, after acceleration ..... 400 fpm
Acceleration — Space to attain 300 fpm ..... 13.9 ft
Acceleration — Time to attain 300 fpm ..... 5.58 sec
Acceleration — Rate ..... 0.9 fps²
Acceleration — Force per 100 lb ..... 2.81 lb

3. *Design computation three*

AISE Specification for Motor Size
CO 1830 Motor — 65 hp — 30 min — 700 rpm
Gear reduction 20 to 1 ..... Balanced
Desired crane speed, after acceleration ..... 333 fpm
Expected crane speed, after acceleration ..... 333 fpm
Acceleration — Space to attain 333 fpm ..... 11.7 ft
Acceleration — Time to attain 333 fpm ..... 4.2 sec
Acceleration — Rate ..... 1.32 fps²
Acceleration — Force per 100 lb ..... 4.14 lb

4. *Design computation four*

AISE Specifications — Roller Bearing Axles
CO 1830 Motor — 50 hp — 30 min — 525 rpm
Gear reduction 18.4 to 1 ..... Balanced
Desired crane speed, after acceleration $\frac{300}{0.9}$ ..... 333 fpm
Expected crane speed, after acceleration ..... 333 fpm
Acceleration — Space to attain 333 fpm ..... 10.3 ft
Acceleration — Time to attain 333 fpm ..... 3.70 sec
Acceleration — Rate ..... 1.50 fps²
Acceleration — Force per 100 lb ..... 4.7 lb

5. *Design computation five*

Bridge motor next size larger than calculated
CO 1831 Motor — 75 hp — 30 min — 500 rpm
Gear reduction 20 to 1 ..... Balanced
Desired crane speed, after acceleration ..... 300 fpm
Expected crane speed, after acceleration ..... 300 fpm
Acceleration — Space to attain 300 fpm ..... 5.55 ft
Acceleration — Time to attain 300 fpm ..... 2.22 sec
Acceleration — Rate ..... 2.25 fps²
Acceleration — Force per 100 lb ..... 7.1 lb

The sample computations and the test cited in this paper show that when motors are selected to give a particular bridge speed, that speed will be attained only when the gearing is so designed that the torque required to overcome the friction of the crane is equal to the torque being delivered by the motor at the motor speed corresponding to the specified speed of the crane. Only one gear ratio will give this result with a specified motor, and specified crane weight, friction factors, axle and wheel sizes.

The actual motor size to be selected will depend on the required duty of the crane, but it must be large enough to have heating capacity for the duty cycle under which the crane operates. The AISE formulae have been selected to give adequate heating capacity for average conditions, but for light duty cycles the motor may be larger than necessary, and on very heavy duty cycles, motors may be too small. The AISE sleeve bearing formula will not give the design speed as intended, but the roller bearing formula will give the correct speed. All formulae are only as accurate, however, as the assumptions on friction and traction.

None of the formulae are set up to give any particular acceleration, and a required acceleration could only be determined by cut-and-try. However, in the case of acceleration, provided the proper gear ratio is computed, the larger the motor that is selected, the greater will be the acceleration. The accelerations computed in the examples in this paper apply only while the motor is on the resistor and do not correspond to the overall acceleration. The latter can be determined only from the motor speed-torque curves.

A 2,000,000 VOLT X-RAY INSTALLATION

. . . . high voltage x-ray equipment imposes many construction requirements in order that safe operation is insured . . . .

By LOVELL CARDENAS
Radiographer
Midvale Company
Philadelphia, Pennsylvania

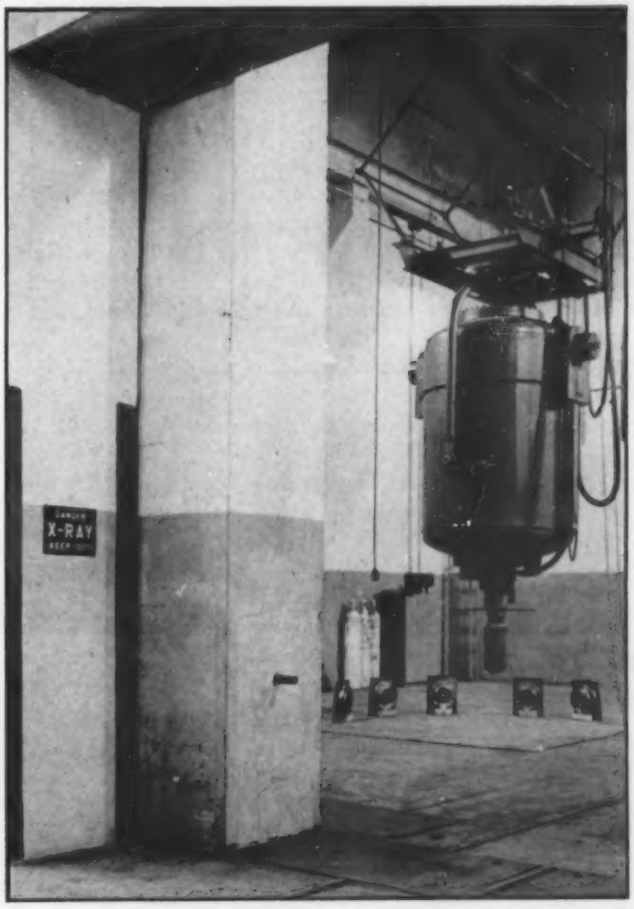
▲ ONE of the basic problems involved in the design of an installation for super voltage radiography is the erection of a building specifically adapted to the type of x-ray work contemplated and the voltage to be applied to the x-ray tube. The greater the variety of work and the higher the voltage, the greater the complexity of the problem. It becomes essential that building, electrical and radiation codes and standards be exactly complied with in order that the personnel may perform their duties unhampered by electrical or radiation hazards.

In the Midvale installation the last word in safety provisions have been incorporated in the x-ray building. In order that the 2000 kv x-ray unit could be operated with the mobility built into it, a wall of dense, reinforced concrete 33 in. thick was constructed partially within the existing No. 2 test cutting machine shop. It was required that the concrete be free of voids with the limiting maximum aggregate size of 2 in. The structure was made 42 ft 9 in. wide inside, 48 ft 10 in. long inside and 33 ft 3 in. high from floor line to bottom chord of roof trusses. The design involved what has become more or less standard practice, the use of a maze entrance from the control room to the main building, and a massive 75-ton, 33 in. thick concrete door constituting a movable barrier between the No. 2 testing cutting machine shop and the x-ray tube.

By the use of the maze, a combined total of 66 in. of compacted concrete barrier is between the control panel and the x-ray tube. This thickness is enhanced when the line from the tube target to the center of the control panel is other than normal to the plane of the maze wall.

The fabricating of the 75 ton door was an interesting application of engineering skill. The interlacing network of reinforcing rods was first wired together and the forms bolted in place around it. The assembly rested on a temporary cribbing a few inches higher than its final position and the pouring was done with a canvas "elephant trunk." The pouring of this door, like the intermittent pouring of the wall, required the grouting

Figure 1 — A maze entrance was used for the opening to the x-ray room to eliminate reflected rays.



Presented before AISE Philadelphia District Section Meeting, November 2, 1948

of the set concrete to insure continuity of the set concrete with the fresh. Following completion of the pouring the concrete was allowed to set and then the wheel trucks and motor frame were bolted in place and the door lowered until the 3 double flanged wheels rested on the single track in the sub-surface pit. A 5 hp a-c motor spur geared to one of the wheels provided the motive power. A double set of limit switches at either end of the door travel and a set of bumpers housing heavy compression springs provide against harmful effects from any overtravel of the door. Previous experience indicated that the plan of spacing the 3 supporting wheels equidistantly to bear equal portions of the load was not the ideal but would lead to driving difficulties. It was found empirically that by permitting the center wheel to bear the largest portion of the load, and one end wheel to be lightly loaded, the remaining wheel could be made the driver and smooth action obtained thereby. This end was achieved by judiciously spacing the 3 wheels. The desirable feature of the door besides its motional facility is its marginal overlap on 4 sides of the doorway to minimize possible exit radiation. This is particularly significant in view of the fact that the radiation from the 2000 kv x-ray tube is emitted in a spherical pattern and results in scattered and rescattered radiation from the materials of the building whose ultimate direction is largely indeterminate.

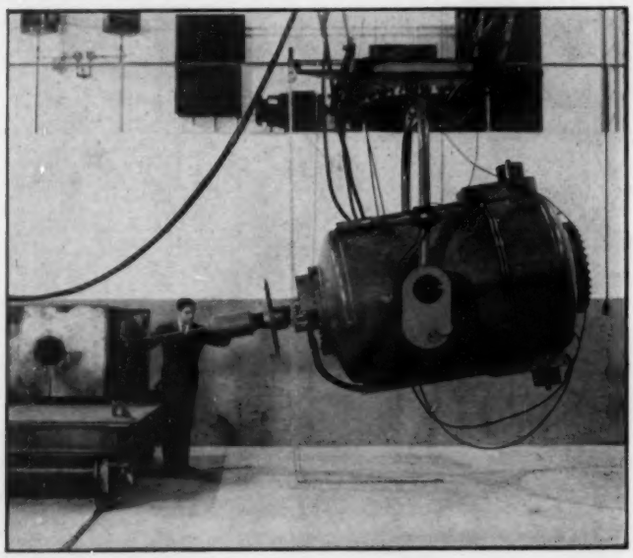


Figure 2 — Heavy castings are rolled up to the table head on a flat car.

In order that massive castings and forgings subject to radiography by this equipment could be handled properly, tracks were laid within the x-ray building which extended out into the loading pit permitting a flat car to be loaded in the pit by a 10-ton bridge crane in the test cutting shop and then hauled within the building by a 2000 lb capacity jib truck.

The x-ray tube and high tension transformers are mounted in a steel tank fitted with trunnions to a fork that is affixed to a frame that can be hoisted by means of motor-driven cable drums on the cross-travel carriage which rides on the supporting bridge crane. A pantagraph provides for motional stability of the tube head by rapidly damping out oscillations and eliminating any turning. Thus by means of a motor hoist, an angulating motor and chain pulleys, the x-ray tube can be rotated about a horizontal or vertical axis and traversed in 3 mutually perpendicular directions. The dimensions of the building housing the x-ray tube are such that a maximum use of its inherent mobility and maneuverability can be achieved.

The 2000 kv, 1.5 milliampere x-ray unit installed at Midvale is extremely flexible and compact. It consists essentially of a 180 cycles per second resonance transformer and a coaxially mounted multisection x-ray tube within a steel tank. Insulation against flashover is obtained by the use of freon-12 (dichlor-difluoromethane) under 60 psi as a dielectric. The use of freon-12 actually makes possible the portability of the unit since a weight reduction from 40,000 lb of insulating oil to its equivalent 260 lb of freon-12 is effected. In addition the freon-12 acts as a coolant for the dissipation of heat from transformer and x-ray tube.

The x-rays are emitted from the target located at the end of an extension chamber projecting from the bottom of the tank. The resonance transformer primary consists of 2 flat coils of rectangular wire and the secondary is made up of 243 thin hollow disc sections stacked to form a hollow cylinder. The coil has an inductance of such value that it is in resonance with its terminal and distributed capacity at the operating frequency of 180

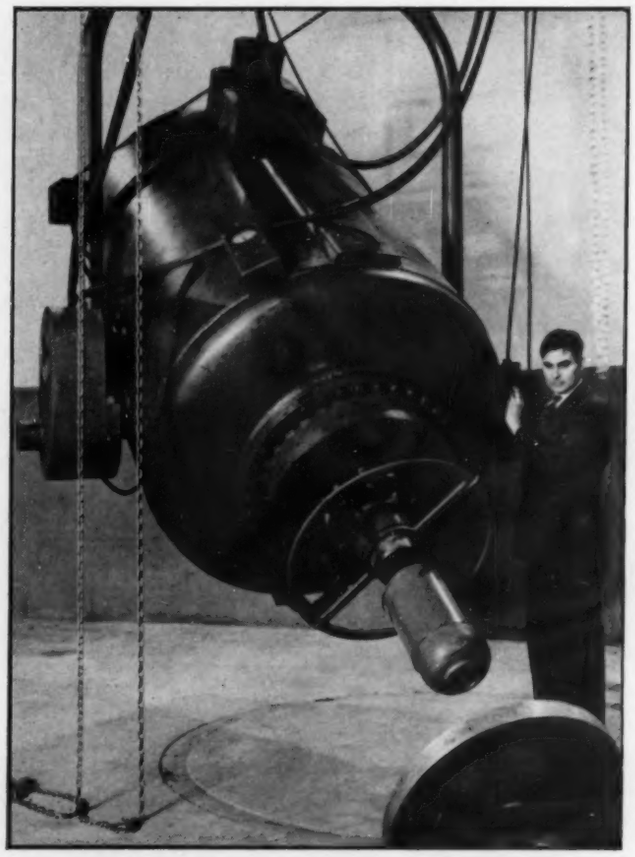


Figure 3 — Close-up view of tube head.

cycles per second. To build this 151 kva resonant system up to the large amplitude of oscillation of 2000 kv requires the relatively small power input of 5.3 kw which is made up of losses in the transformer and power for the x-ray tube and hence can be furnished by the small primary winding placed at the grounded end of

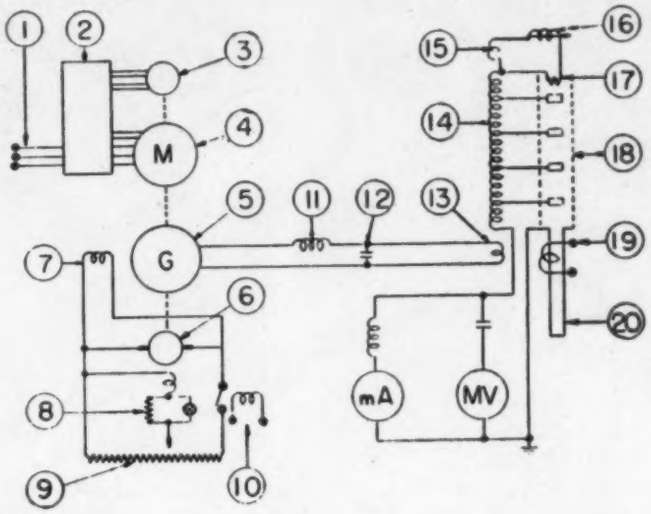


Figure 4 — Diagram of tube head (courtesy G. E. X-Ray Corp.).

the high tension winding. The inductance required for resonance can be obtained in a coil of this size without the use of an iron core and the central space of the high tension coil can accommodate the x-ray tube and incidentally provide electrostatic shielding of the tube. The weak magnetic field parallel to the tube axis does not interfere with the focusing of the electrons.

The tank diameter of the resonance transformer is approximately 62 per cent that of the conventional iron core transformer and the volume is about 44 per cent. A desirable characteristic of the system is that the waveform is always sinusoidal regardless of input voltage variation. Since the magnitude of the oscillating current in the secondary is large (131 root mean square milliamperes at 2000 kv peak) compared to the half-wave full load tube current, operation of the tube produces an inappreciable difference between the positive and inverse portions of the voltage wave.

Overheating of the steel tank is eliminated by employing an inner lining of narrow overlapping silicon-steel strips spot welded to the tank wall. This prevents formation of eddy currents.

In a resonance transformer where the oscillating power is 151 kva and the load is approximately 6 kw maximum, the voltage takes a few cycles to build up even in event of sudden switching of the equipment. Hence switching surges and other disturbances do not raise the output voltage more than a fraction of 1 per cent whereas in ordinary transformers 50 per cent or greater voltage surges may occur as a consequence of improper switching. The non-linear spacing of the secondary coils results in a uniform voltage gradient.

The tube envelope consists of 24 sections of molded borosilicate glass tubing fused to fernico rings to which are affixed the stainless steel intermediate electrodes. The electron emitting filamentary cathode is mounted inside an electrostatic focusing cup at the upper high tension end of the tube. The copper backed tungsten target mounted in the lower end of the extension chamber is perpendicular to the tube axis and electron stream. A metal flange bolted to the bottom of the grounded metal tank and soldered to the copper extension chamber supports the tube. Subsequent operational stability is achieved by a carefully controlled degassing of all glass and metal parts in a combined heating and evacuation process.

In a typical operating cycle, the motor starter connects the 3 phase, 60 cycle power supply to the separately excited 20 hp synchronous motor which drives the 180 cycle single phase alternator, thereby achieving phase reduction and frequency tripling in one operation. The 180 cycle power from the generator passes through a reactor to a shunt capacitor and thence through a

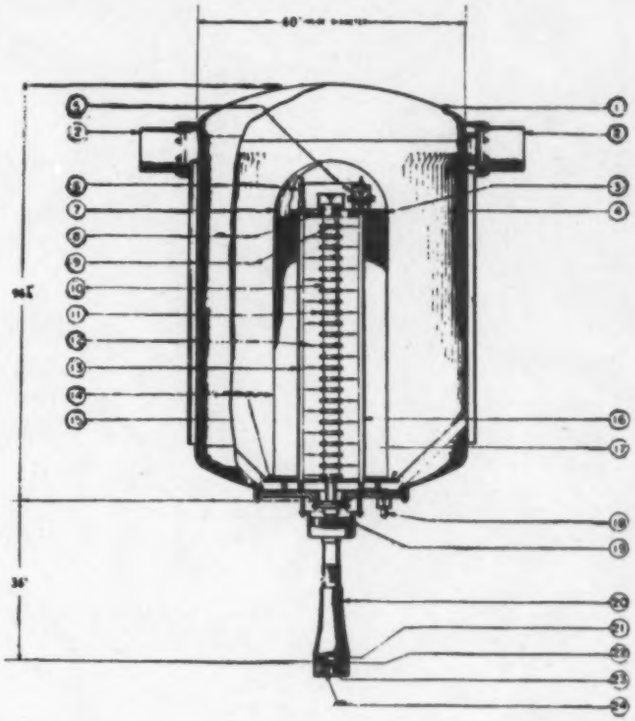


Figure 5 — Schematic circuit diagram (courtesy G. E. X-Ray Corp.).

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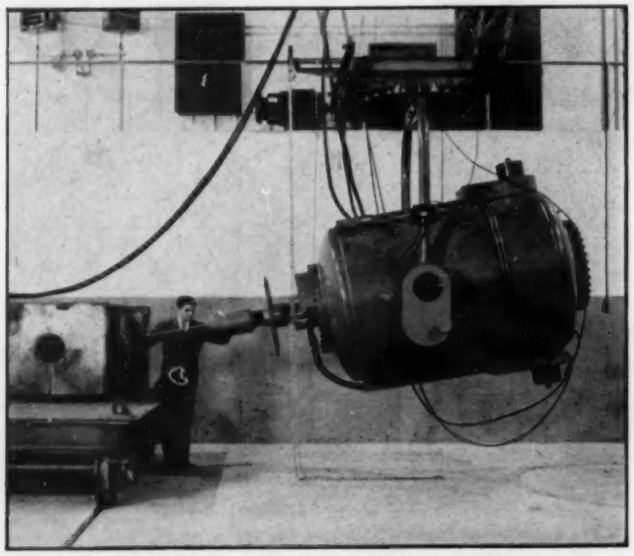

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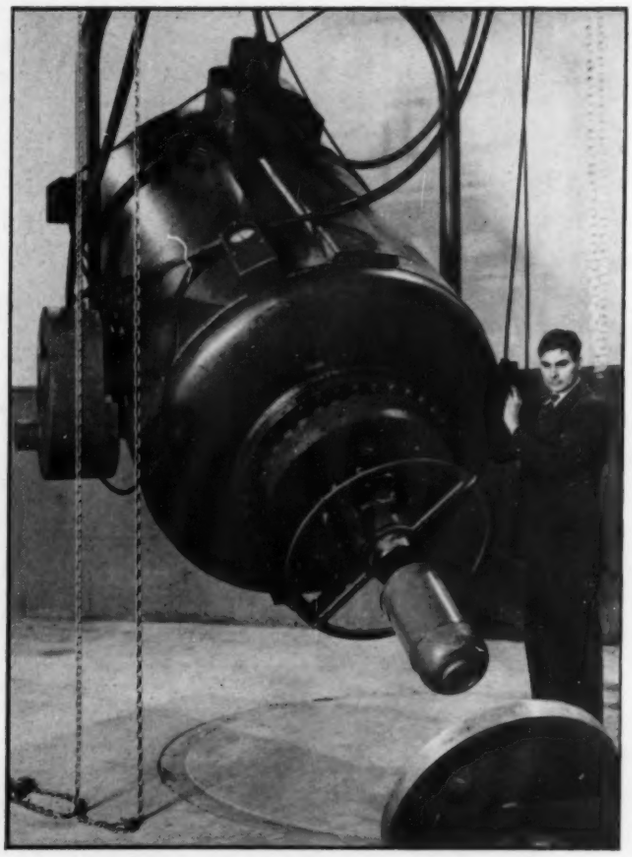

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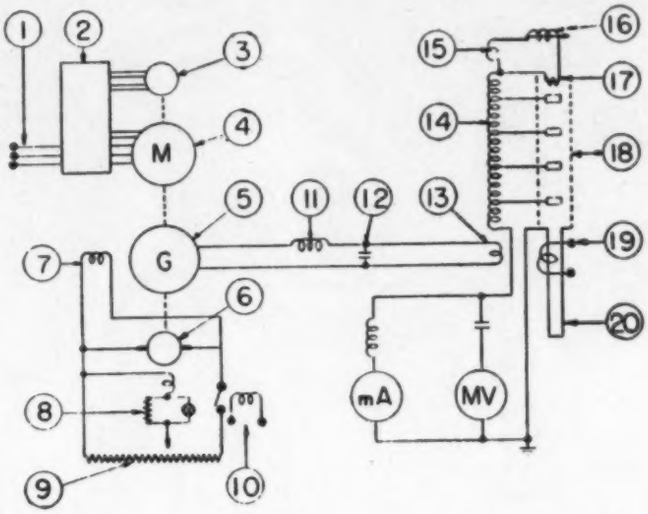

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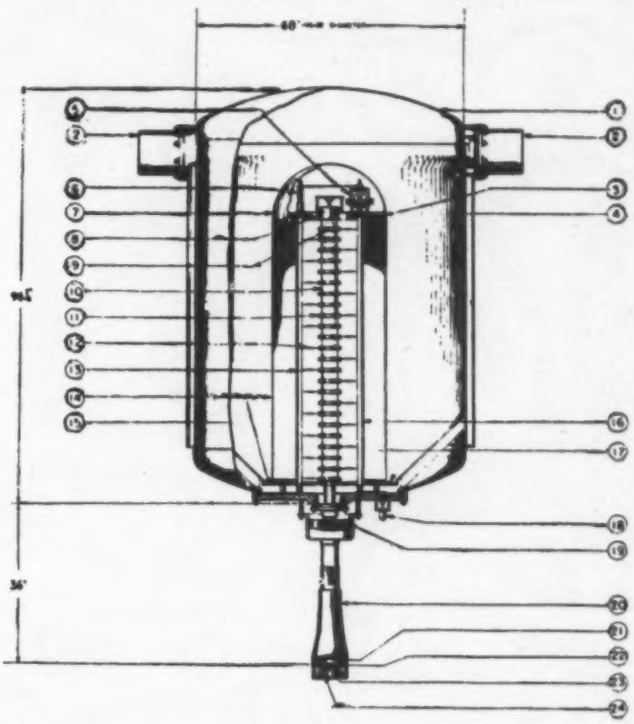

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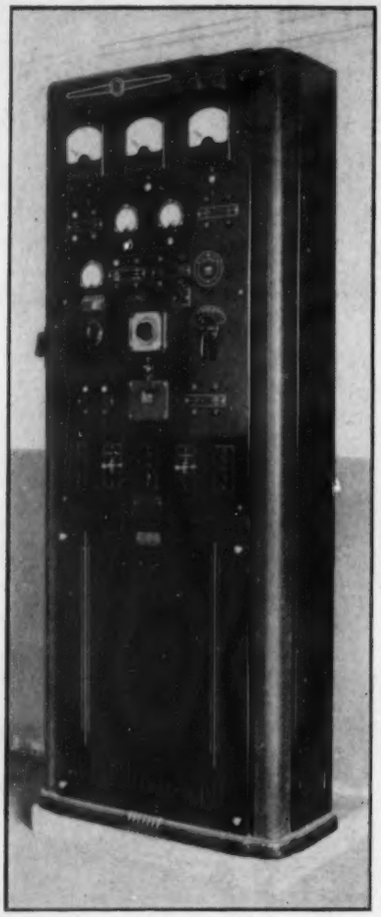


Figure 6 (left) — Control stand for 2,000,000 volt x-ray machine.

Figure 7 (below)— This diagram shows how the intensity and quality is distributed throughout the spherical angle (courtesy G. E. X-Ray Corp.).

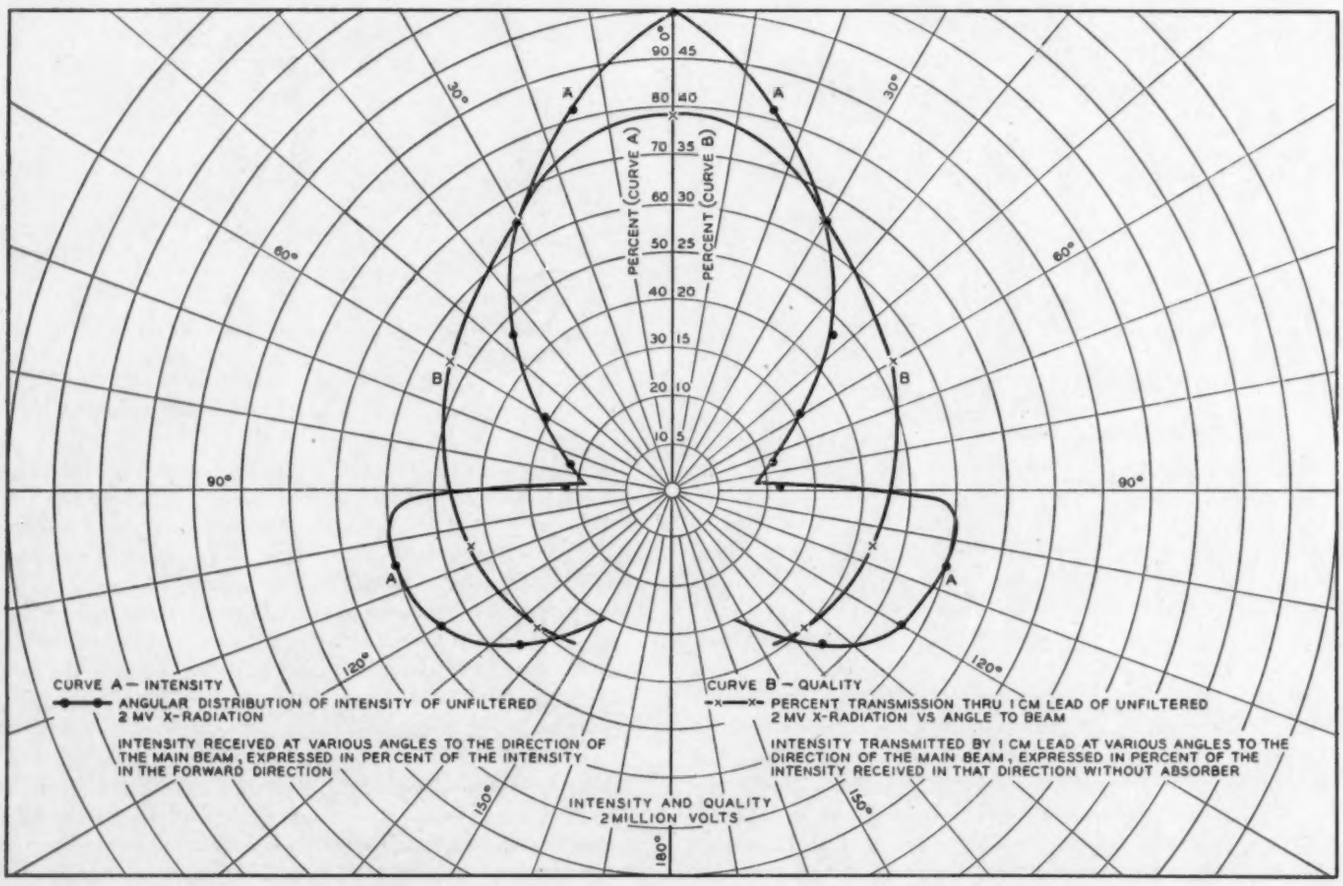
current control is obtained by means of a variable reactor driven by a glass shaft coupled to an external reversible motor. A d-c milliammeter with an inductance in series and an a-c milliammeter with a capacity in series constitute the metering circuit. The electron current of the tube is undirectional and can be read on the d-c meter and the secondary charging current passes through the a-c meter which is calibrated in peak megavolts.

The generator field is connected through a push button "x-ray on" relay to a motor-driven potentiometer connected across the generator exciter. The potentiometer motor is operable from the control panel as is also the filament control motor.

The electron stream is confined to a narrow pencil as it emerges from the tube envelope by the "lens effect" of a d-c solenoid drawing its current from the synchronous motor exciter.

A selector switch on the control panel enables operation at any value from a few microamperes to 1.5 milliamperes and also simultaneously adjusts the d-c through the focusing coil thus fixing the focal spot size on the target for each of the current ranges. Interlocks for the x-ray room doors, the cooler motors, the freon pressure in the tank, the cooling water and fan and pump motor of the heat exchanger are provided. Further an arrangement of relays prevents operation of the unit at overvoltage or current beyond the meter range selected.

This unit with its relative independence of line voltage fluctuation due to its use of a synchronous motor-



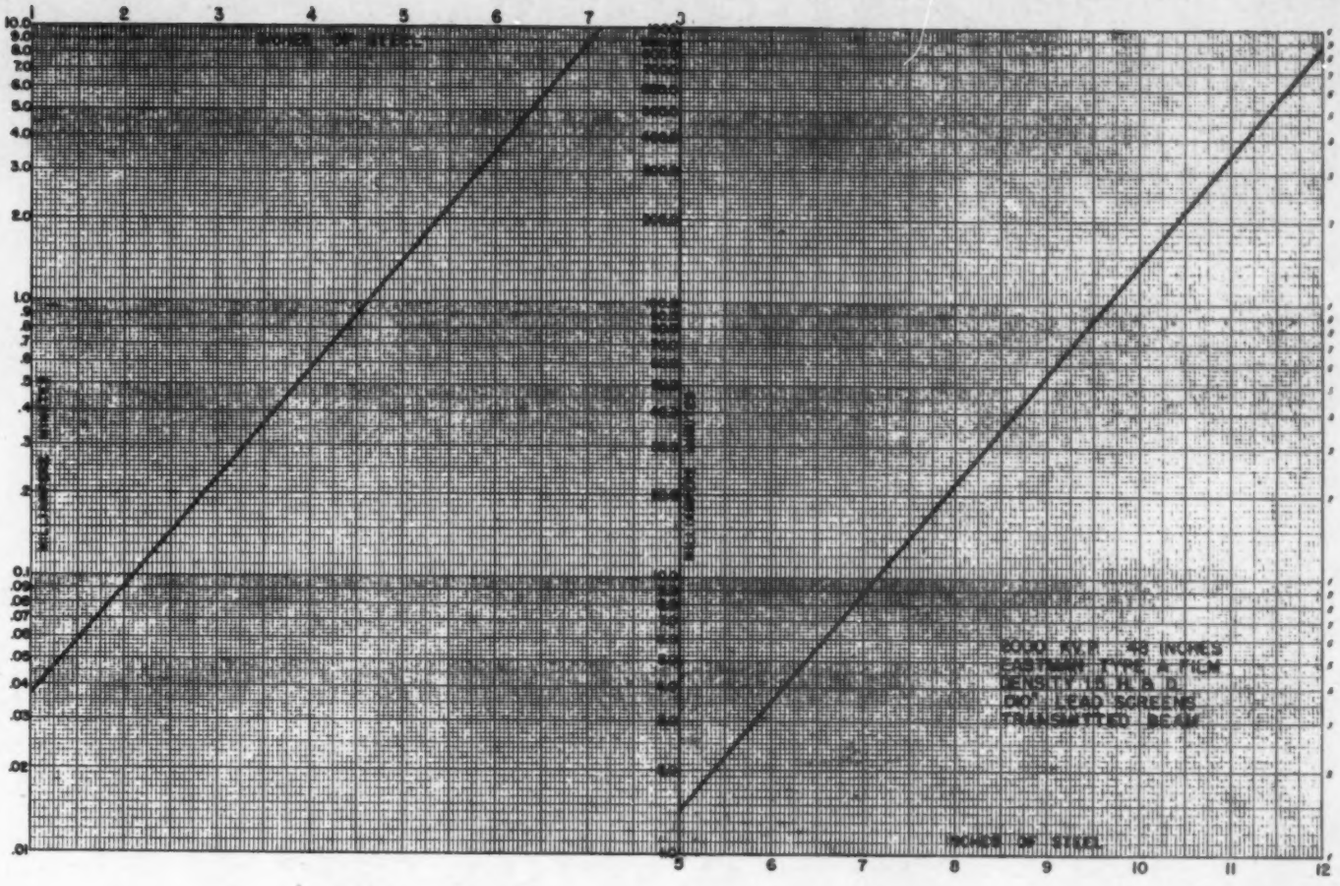


Figure 8 — This chart shows the relation between milliampere-minutes and inches of steel (courtesy G. E. X-Ray Corp.).

driven alternator, its freedom from exposed high voltage and its system of interlocks designed to prevent improper operation is exceedingly reliable from an electrical engineering viewpoint.

The radiation emitted in a global fashion from the target of the 2000 kw x-ray tube varies both in quality and intensity as distinct functions of the angle made with the tube axis. This is a highly significant fact and from its utilization widely diversified radiography is possible. That radiation passing through the tungsten target is termed the transmitted in contradistinction to the reflected radiation which emerges from the electron side of the target. The reflected portion of the beam is relatively rich in the longer wavelength, less penetrative components of the beam. Thus by its use the high contrast effect of low voltage radiation can be secured. Where it is necessary to x-ray objects possessing extreme variation of section thickness, use of the transmitted beam approximates the wide latitude of the gamma rays of radium with the added advantage that the definition of defect image is immeasurably superior. Sections of ¼ to 12 in. thickness can be x-rayed in reasonable exposure times, and a sensitivity of 1 to 2 per cent secured up to 10 in.

The sensitivity of a radiographic process is a quantitative measure of the limiting size of defect detectable. It is achieved by the combination of the 2 factors of contrast and definition. It is not possible by changing the spectral characteristics of the x-radiation in any given case to better both these factors simultaneously since they are inversely related. Whereas contrast is a function of absolute density differences between adjacent areas of a radiograph, definition is a function of the rate of change of density.

Thus once the subjective faculties are adjusted to deducing information from a given radiograph, it is a small matter whether the defect has been rendered perceptible by virtue of its contrast or its definition. The desideratum is sensitivity regardless of the mechanism of achieving it.

Despite the fact that the focal spot in order to insure long tube life is relatively large (up to 12 mm in diameter) the high intensity of emitted radiation makes possible radiography at great focal film distances, the greater parallelism of the rays corresponding to a smaller effective focal spot size. It is from this characteristic that the excellent definition of the 2000 kv radiograph results, coupled with the fact that at this voltage the scattered radiation is to a great extent in the forward direction parallel to the primary beam.

The 2000 kv low frequency resonances transformer x-ray unit in reality is a multirange outfit. Its highly penetrative transmitted beam gives it ready access to the inner structure of castings and forgings considerably beyond the range of even the similar 1000 kv unit. For the examination of non-ferrous material, such as aluminum it is merely necessary to use the reflected beam to achieve the contrast of low voltage x-radiation.

The exceedingly great penetration of the transmitted beam tends to lessen the relative exposure differences in x-raying a multi-section object. Thus time consuming

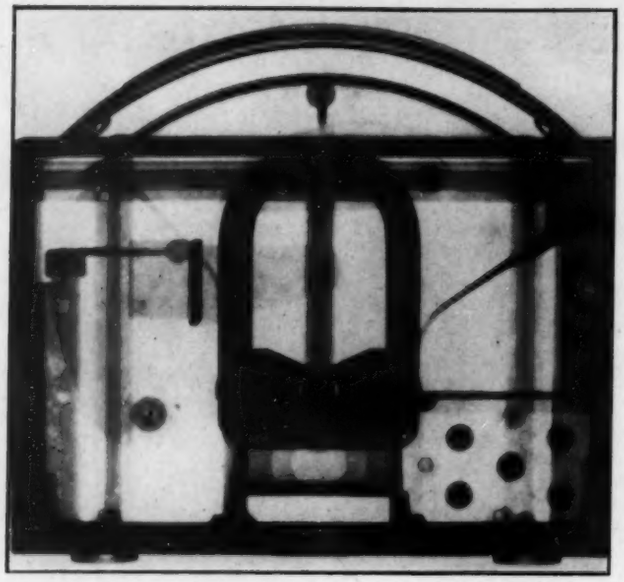
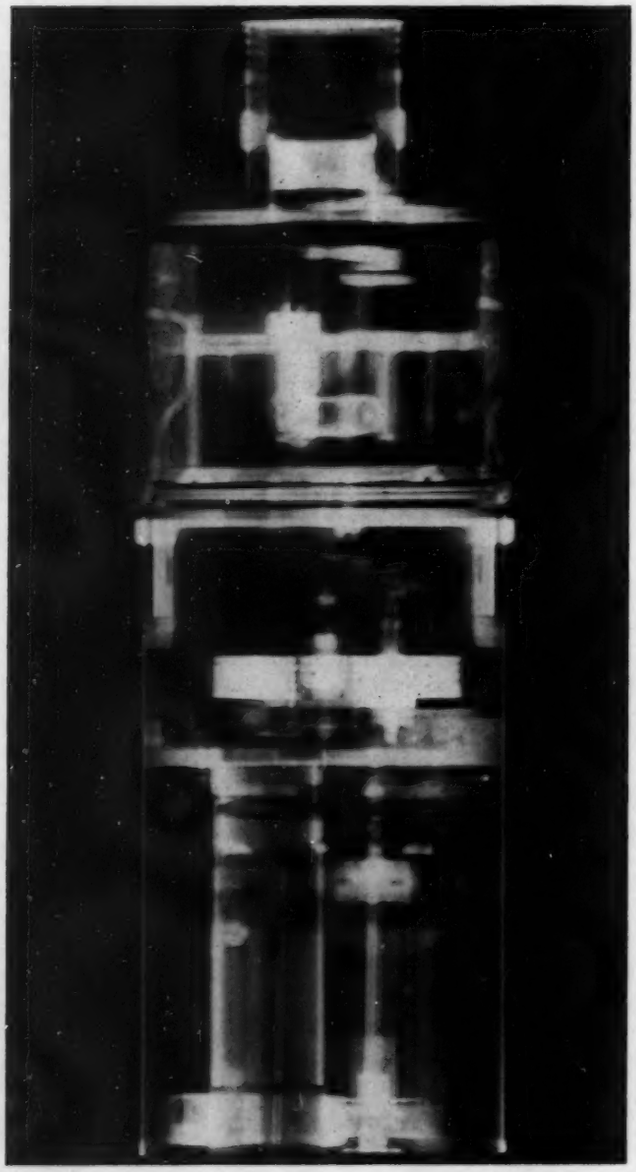


Figure 9 — Instrument used for measuring temperatures.

Figure 10 — Pyro-optical instrument.

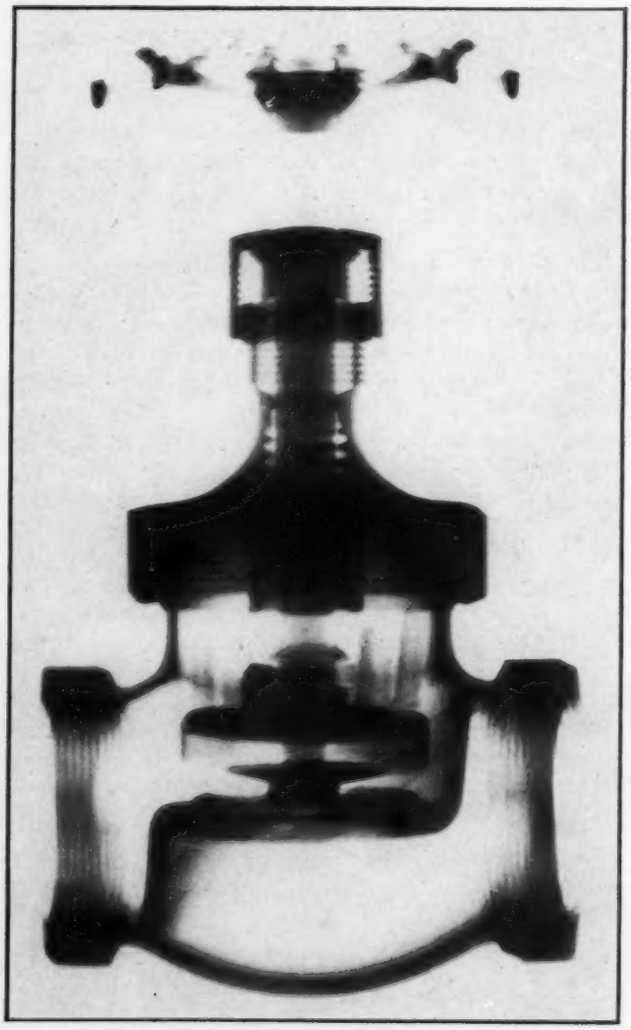


blocking is largely reduced. Due to the large spherical angles available for radiography, a large number of castings can be examined at each exposure.

The development of fine grained, high contrast film used in conjunction with lead filter-intensifying screens has been peculiarly suited to 1000 and 2000 kv radiography. The filter screens generally 0.005-0.010 in. thick provide an intensification factor of 3, and serve to produce a sharper and finer detailed radiograph. The high intensity of the 2000 kv radiation makes meaningless the use of the high intensifying calcium tungstate screens which were resultant in relatively unsharp radiographs due to image diffusion. It has been found that a higher average film density is required in 2000 kv radiography than is customary with lower voltage technique.

In general, x-rays in passing through matter undergo the following changes: some are absorbed through the photoelectric process; some are simply deviated from their path without changes of wavelength; some are scattered through the Compton process imparting some of their energy to electrons and then continuing in new directions with increased wavelength; some are transformed into pairs of electrons and positrons endowed with kinetic energy in addition to their mass equivalent

Figure 11 — This x-ray of a 2 in. globe valve took one minute.



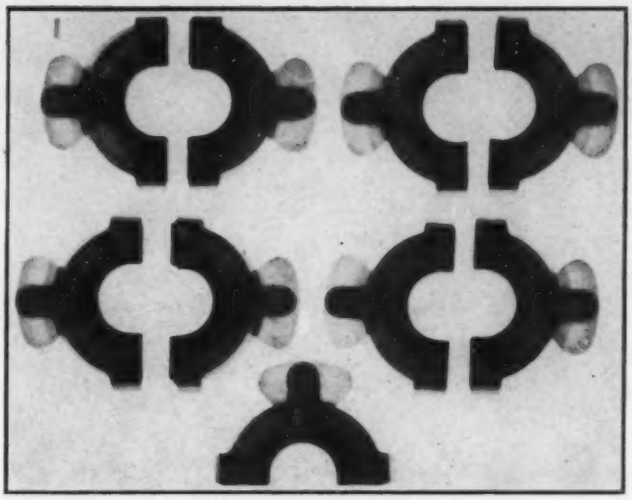


Figure 12 — These are small gland cases for gas turbine applications.

energy when the energy of the pair creating photon exceeds 1022 kfv. These are the primary phenomena. It is apparent that in going through an absorber the photons produced in the primary reactions will undergo similar changes. In addition some of the resulting high energy electrons will produce x-rays. The positrons soon combine with electrons and disappear — are annihilated — producing photons of equivalent total energy. From these considerations it is clear that the passage of x-rays through a thick layer of matter is a very complicated process and the scattered radiation generated on and in a casting being x-rayed becomes a factor to contend with.

Essentially the control of scattered radiation involves the use of collimating cones at the tube target or lead diaphragms on the object to restrict the area of the incident primary beam and the use of filtration at the target or between the film and object. For irregular complicated castings, the double filter technique in which lead filters are used both at the tube port and between the object and film is apparently the ideal. The increase in film clarity obtained thereby by the reduction in scattered radiation more than counterbalances the theoretical predictable loss of contrast through the use of high voltage x-radiation.

Filtration at the tube port serves to eliminate the softer components (longer wavelengths) of the radiation spectrum. This tends to increase the latitude of the radiograph. As much as 1 in. lead filtration at the target has been used to reduce subject contrast with desirable results in the 2000 kv radiography of irregular castings.

The use of lead masking on the object is generally to be preferred to "coning" of the primary beam because the consequences of uncertainty in centering the x-ray tube are not so serious. Eccentricity of the central ray when collimating cones are used to confine the primary beam to a desired area may result in an extremely nonuniform radiograph. This difficulty can be overcome by a well designed pilot light which indicates the central ray of the tube and stabilizes the tube's position. Improper design of cones introduces scattered radiation from the cones themselves which contributes to film density but not defect image formation.

Placing ⅛ in. lead between film and object in conjunction with tube filtration has been used with good results. The lead in the film reduces much of the secondary radiation proceeding from the object in random directions and this immeasurably improves radiograph clarity.

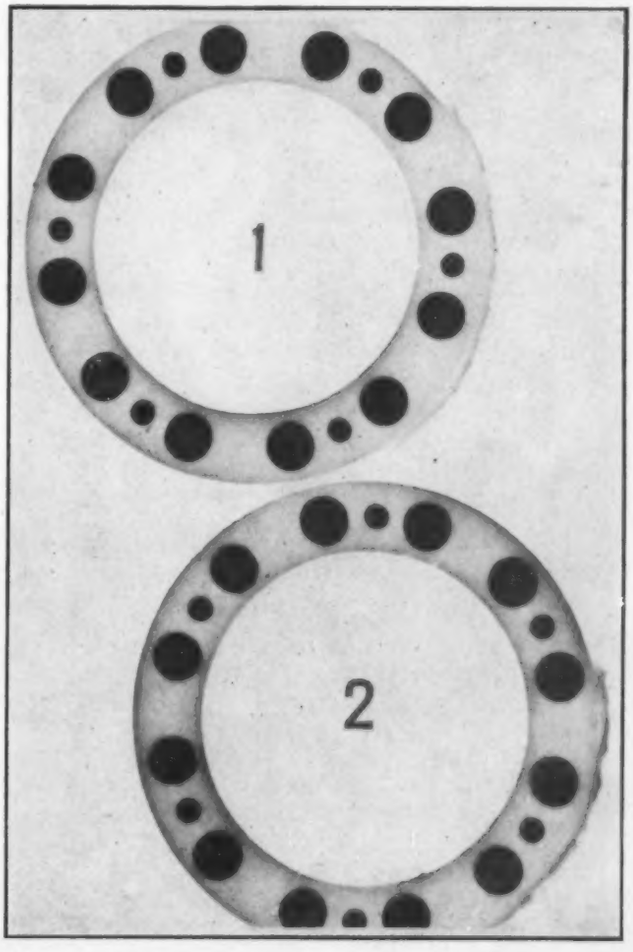
Shot blocking with 70 mesh (approximately 0.015 in. diameter) spherical copper or steel shot has in some cases proved to be the ideal material for compensating for differences in section thickness. The size is such that uniform packing is attained without objectionable granularity or mottling. Edge "halation" can sometimes be greatly reduced by judicious shot blocking.

By operating the unit with a radiation limiting sleeve mounted around the extension chamber, the radiation is confined to a more determinate area. Thus scattered radiation from concrete walk can be avoided with its disadvantage of creating film fog which at this voltage is excessive. For the routine radiography of large numbers of small castings it has been found desirable to cover a portion of the concrete floor with ¼ in. sheet lead. If this is not done, backscatter from the concrete would partially or completely obliterate the detail of the radiograph.

This 2-million volt unit provides the ideal nondestructive testing method for the following purposes and types of work:

1. Castings of steel and other high density metals of complicated shape and of great variation in section thickness from ¼ to 12 in., particularly those of

Figure 13 — Fuel manifold castings.



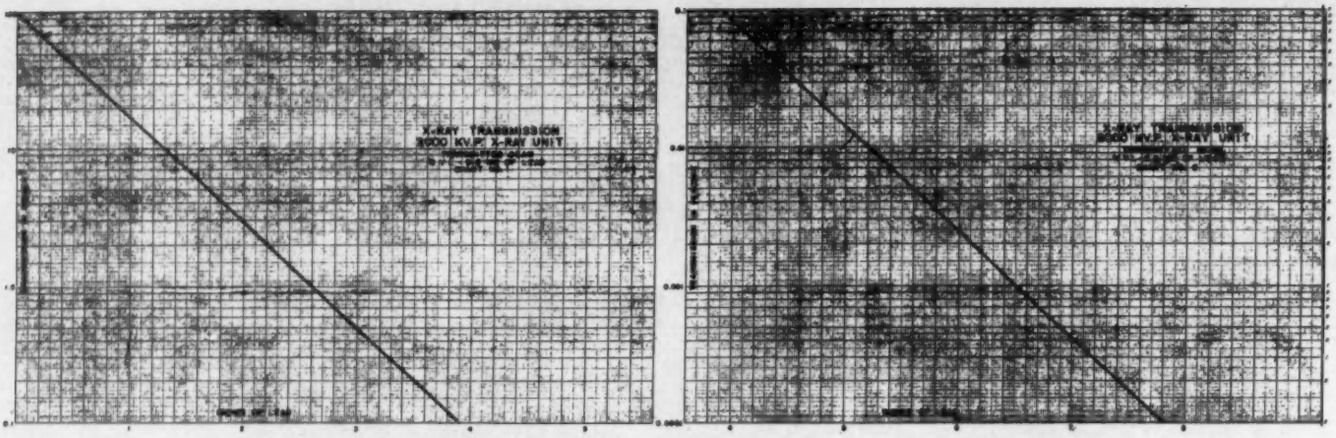


Figure 14 — Transmission of 2000 kv x-rays through lead (courtesy G. E. X-Ray Corp.).

large section thickness, also high pressure and temperature applications for alloy steel and nonferrous castings and pilot castings for foundry control and ingot mold design problems.

2. Forgings of steel and other high density metals containing highly stressed areas in inaccessible locations which are difficult to manufacture, and whose failure in service would be costly and of serious consequence. It is sometimes desirable before further machining to determine whether or not if apparent surface cracks extend to a significant depth in an expensive forging. The radiographic inspection of highly stressed alloy forgings designed so that routine inspection does not disclose serious internal defects is definitely indicated. Gas turbine forgings are illustrative of this where the failure of some small, relatively unimportant part may lead to extensive damage.

3. Weldment inspection of all types, particularly those for high temperature and pressure vessels of wall thickness in excess of 5 in.

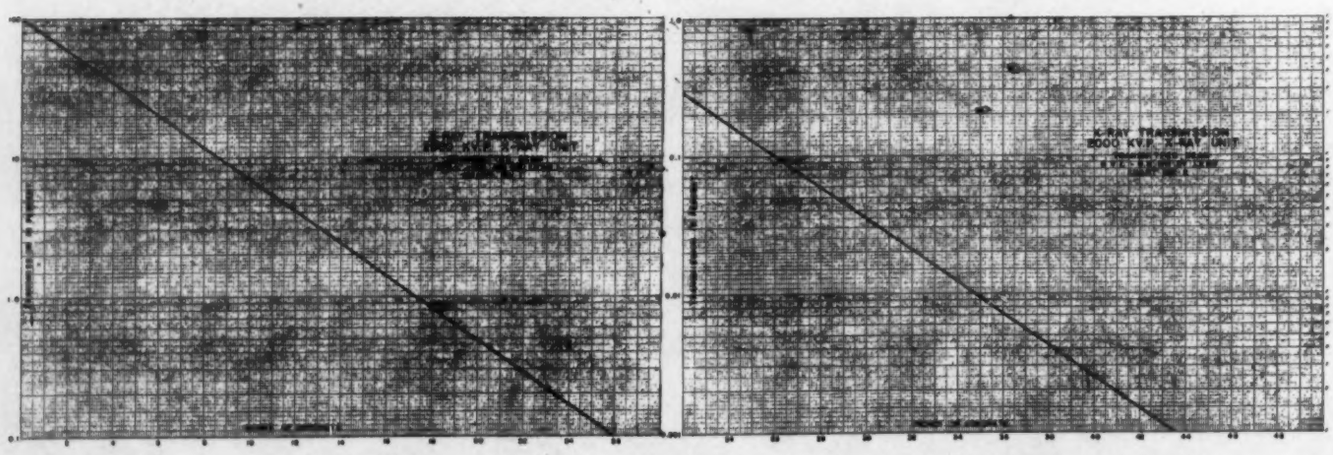
4. Billets, blooms and bars of steel, and other high density alloys, of thicknesses up to 12 in. where a high degree of homogeneity is desired or where a knowledge of the condition at an intermediate stage of the manufacturing process is valuable from a development or control standpoint.

5. Reduction of machining costs by revealing defective areas that subsequent machining would uncover. In many cases chipping and welding in the indicated areas will give a satisfactory product.

6. Minimizing the necessity for overdesigning by using material of a definitely known soundness.

It is not to be inferred that the primary purpose of radiography is the selection of the defective from the acceptable in the case of castings, forgings and weldments. It also performs the positive function of indicating how to apply a repair process to salvage the defective parts. Heavy castings containing mild shrinkage areas may be scrapped if subsequent machining runs into them. Thus radiography can minimize useless machining cost. The list of applications cited is by no means complete but is intended to indicate the salient types of work adapted to radiography by the 2-million volt x-ray unit. Time will undoubtedly multiply the list.

Figure 15 — Transmission of 2000 kv x-rays through concrete (courtesy G. E. X-Ray Corp.).



DISCUSSION

PRESENTED BY

H. H. ANGEL, Electrical Department, Bethlehem Steel Company, Sparrows Point, Maryland

M. B. ANTRIM, Electrical Engineer, Lukens Steel Company, Coatesville, Pennsylvania

R. W. COUCH, Assistant Superintendent Maintenance, Bethlehem Steel Company, Bethlehem, Pennsylvania

W. A. SMILEY, Electrical Engineer, Bethlehem Steel Company, Steelton, Pennsylvania

C. L. EICHENBERG, Engineer, Electrical Department, Bethlehem Steel Company, Bethlehem, Pennsylvania

LOVELL CARDENAS, Radiographer, The Midvale Company, Philadelphia, Pennsylvania

JACK DOERING, Plant Manager, J. S. Thorn Company, Philadelphia, Pennsylvania

C. R. HAND, Assistant Superintendent of Mechanical Department, Bethlehem Steel Company, Baltimore, Maryland

F. C. SCHOEN, Plant Engineer, The Midvale Company, Philadelphia, Pennsylvania

N. C. BYE, Director of Engineering, Henry Disston and Sons, Inc., Philadelphia, Pennsylvania

LOUIS MOSES, Superintendent Rail Mill and Roll Department, Bethlehem Steel Company, Sparrows Point, Maryland

H. H. Angel: Apparently this equipment has some very fine elements of control of current and voltage. I have a couple of questions to ask in reference to time requirements. For instance, the author mentioned that some testings might take thirty minutes for an x-ray picture. Now, I would like to know how long it would take, approximately, to x-ray an 8 × 8 in. bloom, such as you would roll into rails, and what length could you take at one time. In other words, could you x-ray twelve inches or fifteen inches, or what portion of that? The second question is: Figure 11 shows a globe valve, I believe. How much time was required to make that picture?

M. B. Antrim: Although dealing with x-ray machines has not yet been included in my experience, it would seem as though it would require a relatively long period of time to x-ray a plate such as you might roll on a plate mill. I suppose also that due to the conditions under which this machine must operate, since it has to be perfectly shielded, it would not be possible to make the machine portable. No doubt these restrictions would make it very difficult to use this machine for production inspection of steel plate.

However, I wonder if any work might be done using this x-ray machine toward obtaining a standard of the permissible degree of irregularities in manufactured steel by determining what effect, if any, certain irregularities in sample steel tests may have on their tensile strength.

R. W. Couch: In line with the questions that Mr. Angel asked, I would like to know how you would go about x-raying a rim gear, such as would be on a large ladle crane. The gear would have a bore of 48 in. roughly, and the gear over the teeth would be five inches thick. Could you take that in one picture, or would a series of pictures be required to examine it?

W. A. Smiley: In the description of the 2000 kv x-ray machine the input energy is given as about 5 kw. We have a very much smaller machine rated at 250 kv which requires about 8 kw. In comparing machines, the large difference in efficiency is emphasized when we recall that the larger machine draws its power through a motor-generator set instead of directly from the public service company's lines, thus tending to lower the over-all efficiency of the more powerful machine. It would be interesting to know wherein this marked difference exists.

There is a further novel feature, of the apparatus described. In any series resonant circuit, the voltage produced is the product of the input voltage and the quotient of reactance divided by resistance. If the reactance-resistance ratio is high the input voltage must be under precise control. Further, since the product of capacitive and inductive reactance, to produce resonance, varies inversely as the frequency squared, we are required to very precisely control the speed of our motor-generator set, even when we vary the load on the set by increasing the voltage output. The means by which such stability is secured should be of very general interest.

C. L. Eichenberg: At Bethlehem, we have been operating a million volt unit for over a year and, of course, the problem of installation for operation is similar to that of the two million volt unit. The problem of safety to the operating personnel and those people who may be working in the immediate vicinity of such apparatus is of the utmost importance. Our x-ray laboratory is surrounded by a twenty-four inch concrete wall, and a sliding door, similar to the one described by the speaker, and also a maze in between the control room and the laboratory proper. Then, when we got the machine into operation, we were a bit concerned about the amount of radiation which was present inside the control room, and also out in the steel foundry, which was adjacent to the laboratory. So, we called in a group of physicists and also the head of the radiological division of the Bureau of Standards in Washington, and they performed certain tests, using geiger counters, gold-leaf electroscopes, etc. On the basis of their findings we made some minor changes, such as lining our movable door with a quarter-inch of lead in order to reduce the hazard to men in the foundry. We had a glass block window in the laboratory which was directly in line for reflected rays to strike our film storage room. As such, of course, the film storage room was useless to us until we blocked out the window with a lead shield.

Lovell Cardenas: Glass rod shattering is something which always appeared to be quite a problem insofar as it is known that glass crystallizes under the action of radiation. I have seen the phenomenon in radium emanation plants where the application of heat to the glass so affected would result in its flying apart. It is quite probable that some back radiation might have a similar effect in the tube head of the 2000 kv unit. These rods hold the little flat coil sections of the second-

ary in place enabling the tube to be rotated about a horizontal axis.

In connection with the first question, the exposure time would depend upon the type of defect sought for. If it were gross or if one was merely concerned with ascertaining the presence or absence of a discontinuity an 8 × 8 in. bloom could be radiographed over a 12 in. length in approximately 5 minutes. A greater length could be examined by increasing the focal-film distance but since the radiation at the terminal portions would be traversing a greater effective thickness of metal, the radiograph might appear unduly light in these regions and hence lacking in diagnostic value. If a high intensity illuminator were available, the central part of the section under examination could be overexposed whereas the ends would receive the correct amount of irradiation. In this manner an interpretable film would be secured. Generally speaking the length examined per exposure is a function of the section thickness in question, being inversely related.

The globe valve was radiographed at an 8 ft focal-film distance in one minute. In this instance the tube current was reduced to 5 per cent rated current so that by increasing the exposure time greater accuracy in timing could be achieved.

As far as the use of the x-ray in determining the tensile strength of plates, it might be stated that this is a matter that has not been resolved as yet. Extensive testing of armor plate with this idea in view has resulted in no satisfactory correlation of the radiographic appearance and tensile properties of the plate. Paradoxically, projectiles fired at these armor plates sometimes broke the plate which was radiographically unacceptable less readily than that which the x-ray indicated to be sound.

With regards to the manner of radiographing a 48 in. diameter gear ring, one could achieve this in a single exposure by making use of the reflected beam. However, since the focal-film distance is approximately two feet in this setup, the result would not be entirely satisfactory.

In answer to the question as to why this high voltage x-ray generator is relatively more efficient than lower voltage generators, consider the comparable 1000 kv unit. This unit is energized by a motor-generator set in which the motor is of the synchronous reluctance type. The power factor of this combination is about 0.33 whereas that of the 2000 kv unit is close to unity. The higher efficiency of the 2000 kv unit is a direct consequence of this. As far as low voltage equipment is concerned, there are many types of generating and rectifying systems. There are mechanical rectifiers; two, three and four valve tube circuits; tripler and doubler circuits, etc.; so that it would be difficult to state offhand why one system is more efficient than another. The problem generally stated is that of utilizing a certain amount of the power wave. In full wave rectification, the inverse part of the power wave is reversed and condensers are used to store energy during building up of the voltage wave in order to arrest the subsequent complete decay of the wave and so that an approximation to constant potential for energizing the x-ray tube is secured. In the 2000 kv equipment, the generator independently of the transformer has a maximum at a frequency slightly different than 180 cycles. Since the transformer under conditions of constant current operation has a voltage maximum (is in resonance) at 180 cycles it is desirable that these be matched. This is accomplished by the use of the series reactor and the shunt capacitor between the alternator terminals and the transformer primary.

It apparently is characteristic of the system that it have a stable resonance point at 180 cycles. The total inductance of the secondary is very large being of the order of 12,000 henries whereas the distributed capacitance is only 67 micro-micro farads — these parameters tending to limit the voltage to a fixed value.

Jack Doering: You spoke in one case of taking two photographs, one at right angles so as to obtain exactly where the porosity or blow holes were in a given casting. I would like to know whether Mr. Cardenas has tried taking two views at small angles to get a stereoscopic effect, thereby being able to see directly through the casting by means of a stereoscope?

Lovell Cardenas: I have not taken stereoscopic views, but I have taken two pictures by exposing the casting for half the exposure on the same film, and then displacing the tube target a given amount and knowing the focal-film distance and displacement of the tube, you can compute the depth of the defect. Where you have a defect winding in three dimensions, that is not always satisfactory. The stereoscopic method is always troublesome in production work.

C. R. Hand: What is the effect on radio equipment in the vicinity of these two million x-ray machines?

Lovell Cardenas: No effect whatsoever. It does not radiate radio waves and the frequency is very low.

F. C. Schoen: I would like to make a few comments covering the complete x-ray installation. As Mr. Cardenas pointed out, we have a definite personnel protection problem to consider. Originally so many warning signals and protective devices were considered that it looked like a lot of extraneous headaches were being wired into the x-ray circuits. As finally completed, the protective circuit is rather simple, consisting of interlocks preventing application of power until all doors are closed, the key for the small door being also used to close circuit on switch board. The small door from the control room to the maze is also lead lined to give extra protection to the operator. In starting the x-ray, switch key is inserted in control panel and turned to "ON" position. This starts a timer, which sounds an alarm bell and lights lamps in x-ray room for sufficient time to permit anyone who might be in x-ray room to get out before the x-ray tube is energized. To permit easy exit, the door from maze is equipped with panic style lock bar, so that no one can be locked in.

Another thing we were up against, the x-ray building is about two-thirds inside of another shop. We started worrying about the crane repair men, as they would be in line with some of the x-rays while up on the crane. As a result, we had to fence in certain portions of the runway so that they cannot get near it to make repairs in dangerous areas. Also, we stretched fences across the roof of the building. Even now, we are getting some recommendations from health authorities for additional fences and warning lights outside of the building, in case the tube should happen to point toward a wall, to warn personnel from remaining in that area too long,

as even with the 33 in. concrete wall, possible harmful effects could be had.

When Mr. Cardenas speaks of 3¾ in. of lead as the equivalent of 33 in. of concrete, it is easy to realize our construction problems. We started off with the idea that we could build a lead lined building, but after computing the amount of lead necessary, and how we were going to hang it up, it was decided that the building as described was the cheapest thing, although it does look like a lot of concrete.

C. L. Eichenberg: When we received our unit, we were concerned with somebody being locked in the room, or not knowing that the unit was coming on, so before we put the unit into operation we changed the control circuit. We installed the timer which operates for something like 30 seconds, and then the machine comes on. Thus, if anybody were trapped in the room, he could pull an emergency switch and shut off the x-ray unit, allowing him to come out into the foundry. In the foundry we have a large illuminated sign telling the personnel when the x-ray machine is operating, so that they should remain away from walls of the building.

N. C. Bye: I would like to know the effectiveness of the x-ray in determining whether laminations in plates are really detrimental or not. Can you tell whether laminated plate is really detrimental, as far as the effectiveness as a shield, that is, by x-ray?

Lovell Cardenas: That is one type of defect for which the x-ray is not the ideal instrument. That is, if you had a plate laminated a hundred times, and if the laminations were perpendicular to the x-ray beam, you would not be able to detect them.

In that case the ideal instrument would be the ultrasonic reflectoscope, using inaudible sound waves. What I said before about the inability to correlate internal discontinuity, with tensile strength, satisfactorily, still holds true.

Louis Moses: Is there sufficient energy in the focused ray to create radio activity in the objects being examined?

Lovell Cardenas: No, the voltage is not high enough for that. You have to get up in the region of 30 million electron volts to get radio activity in the castings like that.

IFMA OFFERS TECHNICAL PAPER AWARDS; WINNERS MAY VIE FOR AISE AWARDS . . .

▲ THE Industrial Furnace Manufacturers Association, Inc., 420 Lexington Avenue, New York 17, New York, desires to promote the publication of more and better technical articles in the trade press describing the economic advantages obtained by the use of modern industrial furnaces, kilns, and ovens. To this end, IFMA will award prizes amounting to $1,500 to the authors of the three best articles which are published in the trade press within the period specified, and which meet the following standards:

1. Eligible articles must be published in a trade paper in the United States between October 1, 1947, and September 30, 1948, inclusive.
2. Articles must be original. Technical society papers which are subsequently published in a trade paper will be considered.
3. Articles may be purely technical or semi-technical, but must describe specific advantages obtained by the use of modern industrial furnaces, kilns, or ovens used for heat treating, processing, or melting.
4. The equipment or processes described must be commercially operative and of benefit to users of the industry's products.
5. Competition is open to all except those connected with the industrial furnace, kiln, and oven industry.
6. Papers shall be judged for:
   a. Completeness and accuracy of operating data such as fuel or electricity cost, labor costs, floor space requirements, savings in preceding or subsequent operations, material costs, etc.
   b. Concise and complete coverage of improvements in the product, such as physical qualities, appearance, the reduction of rejects or rework, etc.
   c. Clearness and completeness of description of equipment including size, construction, operating cycle, etc.
   d. Uniqueness of design with regard to method of operation, material handling, heating, etc.
   e. Completeness of description of parts treated, size, material, rate of production, etc.
   f. In general, the ability for a possible user in the same or similar industry to apply these data to his product or operations, and to determine the possible advantages from his use of the equipment or process.
7. The following prizes will be awarded to the authors of the three best articles:

First prize	$1,000
Second prize	300
Third prize	200

   Awards of merit will be given to the publishers of the three winning articles.
8. The awards will be made and checks sent to the authors of the three best articles on or before February 1, 1949.
9. The decisions of the judges shall be final.

Winners of the IFMA prize would also be eligible for the AISE Kelly award, if their papers were published in the *Iron and Steel Engineer* and if they are directly employed by the iron and steel producing industry. Kelly award winners need not be members of the AISE.

Carnegie-Illinois Builds

TWO NEW 1500-TON BLAST FURNACES

. . . . recent figures just released by the United States Steel Corporation on two new blast furnaces are of interest to the engineers and operators in the steel industry . . . .

▲ CONSTRUCTION of two new 1500-ton blast furnaces is proceeding at the South works of Carnegie-Illinois Steel Corporation and it is expected that both furnaces will be blown next spring. A third blast furnace at the Gary works of Carnegie-Illinois has been rebuilt and enlarged to conform to the same dimensions an lines as the new furnaces at South works.

The two South works furnaces are being built as a pair 212 feet-4½ inches center to center, and are located next to an existing group of furnaces. The stock house for this group of furnaces is being entirely rebuilt concurrently with, and will include facilities for, the new furnaces.

The hoist houses are located below the skip inclines at ground level. Six stoves, three for each furnace, are located in line between the hoist houses. Between the furnaces are three gas washers with superimposed precipitators, a pump house and precipitator substation, and a pyrometer house, all common to the two furnaces.

The cast houses are opposite the skip inclines, and between and adjacent to them are the two dustcatchers. Between the dustcatchers is the granulated cinder tank and crane runway serving both furnaces. A passenger elevator is located between the stoves and gas washers.

Main dimensions of these identical furnaces are as follows:

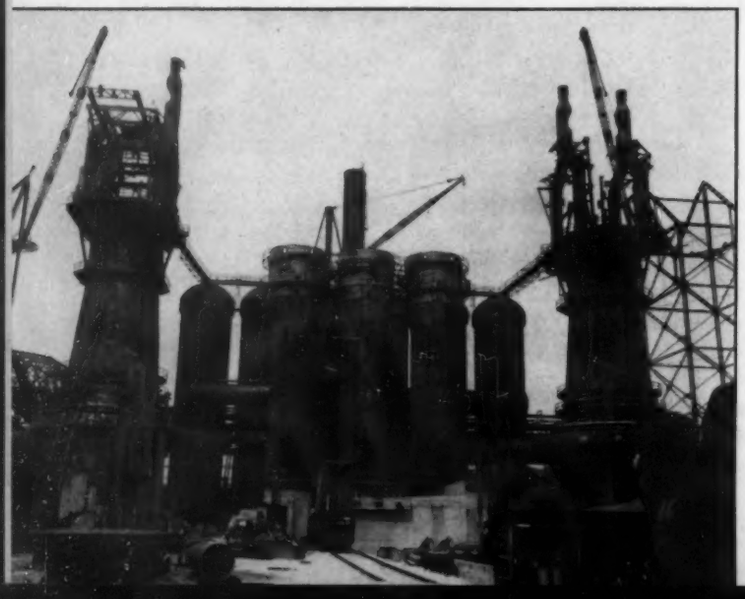
Hearth diameter	28 feet-0 inches
Bosh diameter	31 feet-0 inches
Bosh angle	81 degrees-40 minutes-27 seconds
Stockline diameter	21 feet-6 inches
Large bell diameter	16 feet-6 inches
Height (center line of iron notch to top of top ring casting)	108 feet-0 inches
Number of tuyeres	20

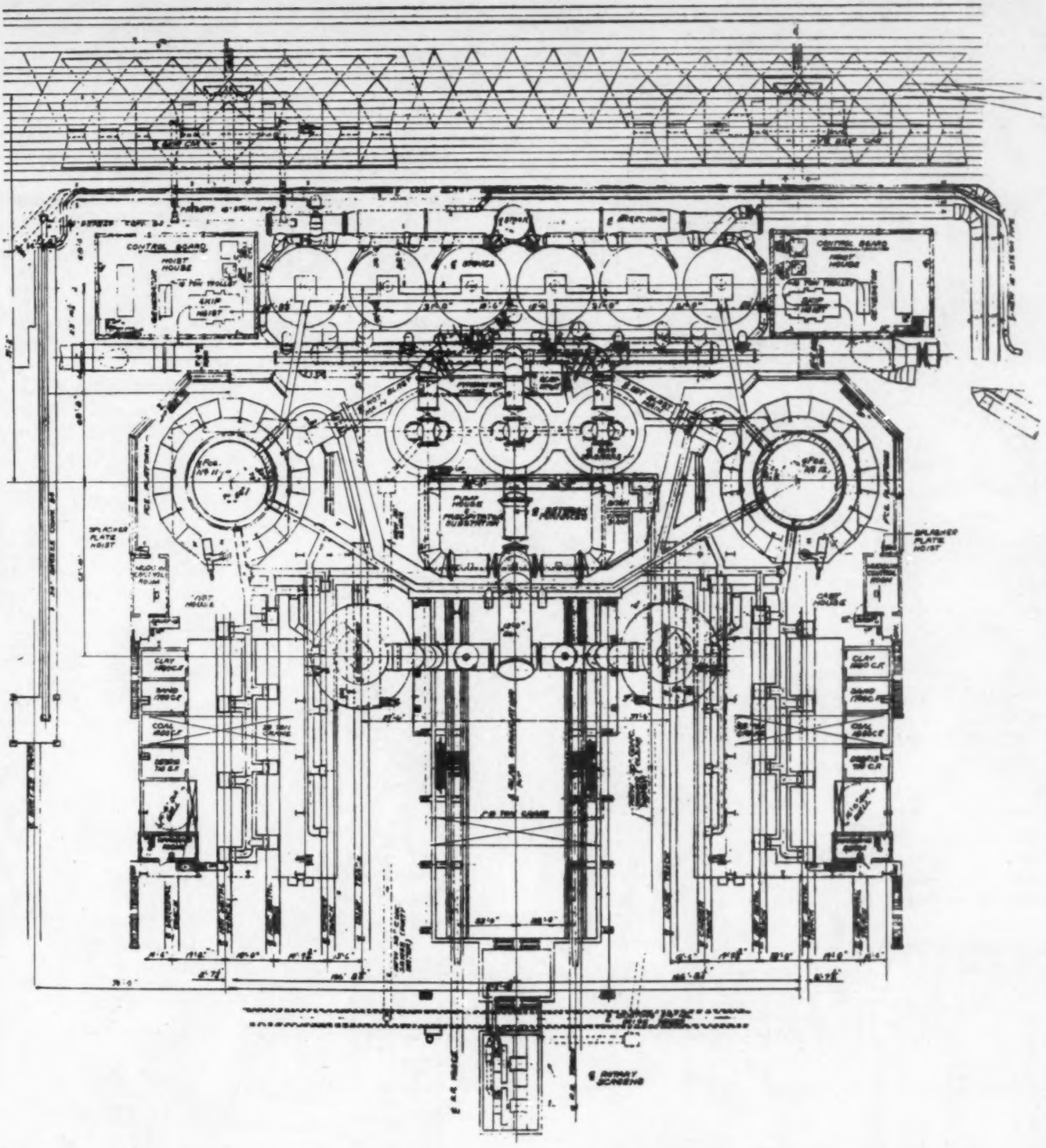
Foundations — Each furnace foundation rests on steel piling, and consists of a poured concrete mass 58 feet in diameter, about 20 feet thick, with a circular opening in the top that is 35 feet-9 inches in diameter and 9 feet-7 inches deep. This opening is floored with a brick pad 2 feet-3 inches thick, and lined with a brick wall 13½ inches thick.

Columns supporting the mantle rest on the foundation, their base being arranged in a circle 43½ feet in diameter. There are eight of these columns, inclined inwardly toward the stack from their bases so that the tops of the columns lie in a circle 39 feet in diameter. The top of the mantle is 36½ feet above the top of the concrete foundation which, in turn, is 8 feet-7 inches above grade.

Hearths — Beginning at the brick pad on the foundation, construction of the hearth continues with seven courses of firebrick, each 1½ feet thick, for a total height of 10½ feet. This is topped with two carbon courses, each 22½ inches thick, composed of blocks of that thickness and 30 inches wide, having a maximum length of 15 feet, each. The sidewalls of the hearth are built with a double wall of carbon blocks, those forming the inner wall being 15 inches thick and those in the outer wall 11¾ inches thick. Altogether, 453 carbon blocks were used in the construction of each hearth. Voids between the blocks are packed with carbonaceous filler. A pad of 18 inches of firebrick is finally laid over the carbon block hearth bottom. The hearth sidewalls of carbon blocks extend 3 inches above the hearth jacket. Between the jacket and the sidewalls, a space of 3¼ inches is filled with tamped tarred coke breeze. The cooling jacket of the hearth is 6 inches thick, and is separated from the all-welded steel-plate shell of the hearth by a space of 2 inches tamped with grout. The

This view shows construction on the two new 1500-ton blast furnaces being built at the South works of the Carnegie-Illinois Steel Corporation. The three vertical structures between the stacks and in front of the stoves are the primary gas washers with superimposed electrostatic precipitators.



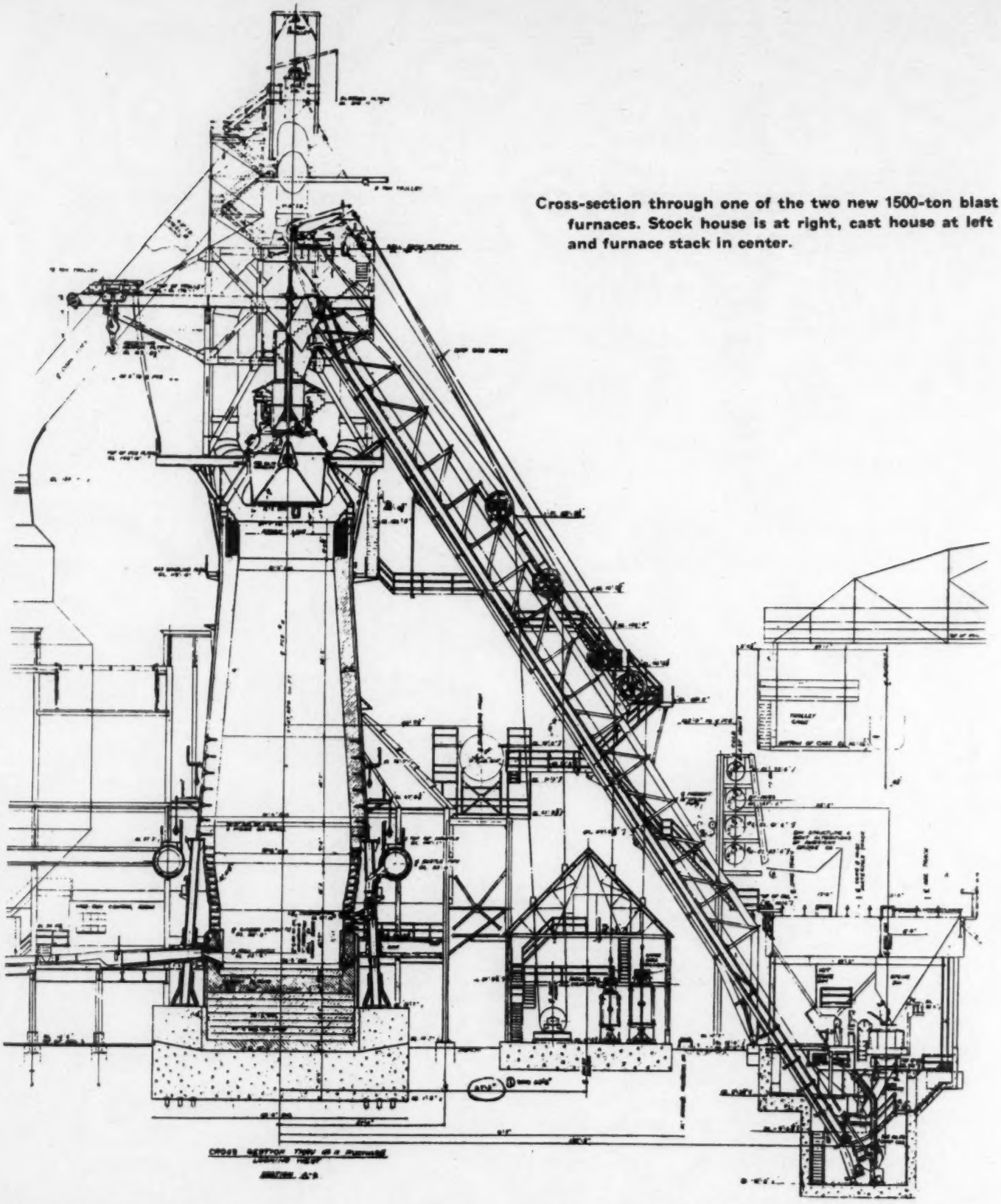


Plan view of the layout of the blast furnaces.

shell is made up of 1½ inch thick steel plates. To protect the carbon blocks of the sidewall during the blowing-in period and for a short time thereafter, a 9-inch firebrick false wall is built as an inner lining for the hearth.

The center line of the iron notch or tapping hole is 20 feet-6 inches above grade, or 5 feet above the surface of the carbon block bottom. Center lines of the two cinder notches are 9 feet-8 inches above the surface of the carbon block bottom, or 25 feet-2 inches above grade. A removable hearth cooling plate is provided at the iron notch. Hearth volume between the center lines of the iron notch and tuyeres is 5130 cubic feet, including the 9 inch protective false wall.

Tuyeres — The tuyeres, 20 in number on each furnace, are inserted radially at 18 degree intervals around the circumference of the furnaces just below the boshes. Center line of the tuyeres is 8 feet-4 inches above the center line of the iron notch, and 3 feet-8 inches above the center lines of the cinder notches. Their internal



Cross-section through one of the two new 1500-ton blast furnaces. Stock house is at right, cast house at left and furnace stack in center.

diameter at the nose is 7 inches. Hot blast is supplied from the bustle pipe through suitable connections to the tuyeres. The bustle pipe is lined with 9 inches of firebrick backed with 3 inches of insulation and has an internal diameter of 5 feet.

Boshes — Starting just above the tuyeres, the brickwork of the bosh, 2 feet-3 inches in thickness, is stepped outward 3½ inches in diameter for each foot of rise, corresponding to a bosh angle of 81 degrees-40 minutes-27 seconds. Each step-out is enclosed by a bosh band consisting of a welded steel ring of proper diameter, 10 inches in width and 1¾ inches thick. Total height of the section is 10 feet-3 inches. Plates for cooling the bosh walls by circulating water are inserted in the

brickwork a total of 280 plates being set in seven rows in each bosh. Additional cooling plates to the number of 118 are inserted in four rows in the hearth wall between the cinder-notch level and the lower bosh line.

Mantles — Each mantle is supported by the eight structural steel columns previously referred to in connection with the furnace foundation. It, in turn, supports the stack. Constructed of 1¼ inch and 1½ inch steel plates, suitably reinforced and stiffened, it was assembled by electric welding.

Stacks and inwalls — From the center line of the tuyeres to the stock line, each furnace has a volume of 47,550 cubic feet. The straight section of the inwall above the upper bosh line rises vertically for a distance of 9 feet; 5 feet below, and 4 feet above the mantle level. At the mantle the brickwork extends to the furnace shell and is approximately 4 feet-0 inches thick. In the sloping section of the inwall, it is 3 feet-4½ inches. One hundred and twelve cooling plates are set in this vertical section in three rows. Above it, in the lower part of the inwall, there are 144 plates set in six rows. The sloping section of the inwall is 57 feet in height and decreases in diameter from 31 feet-0 inches to 21 feet-6 inches, corresponding to an inward slope of 1 inch for every foot of rise. The section of the shaft above the inwall in which the wearing plates of steel are set, is slightly over 8 feet in height.

The steel shell of the stack is of all-welded construction, made up of plates a minimum of 1 inch thick. Between the shell and the brickwork of the stack a space of 3 inches is filled with fire clay.

Top structures — Each top structure is supported on the furnace shell and in turn supports the head sheaves, bell beams, receiving hopper, repair trolley, and platforms. The top platform is 127 feet-10 inches above grade. The top of the gas seal casting is 8 feet above the level of the top platform.

The large cast-steel bell is 16 feet-6 inches in diameter, with a slope of 53 degrees. It has a 2½ foot drop. The hopper has a capacity of 1726 cubic feet. The bell is suspended by means of an 8 inch diameter rod attached to its apex. The small bell is suspended by a bell rod consisting of a sleeve through which the big bell rod passes. The small bell is of cast steel, 7 feet in diameter, and has a 53 degree angle. It is protected by wearing aprons of cast manganese steel. Both bells are air operated through cables for cylinders located in the hoist house.

The revolving small bell distributor has three top rollers, three bottom rollers and three side rollers.

A 75-ton capacity trolley capable of handling the large bell and hopper together is built into the top structure. Maximum travel of the hoist on the trolley is 40 feet from the center line of the furnace. Top of the trolley rail is 163 feet above grade and 35 feet-3 inches above the top of the furnace platform. A 5-ton trolley serves the bell-beam and head sheave platform, which is 173 feet above grade, and the uppermost structure of the top on each furnace carries a 2-ton trolley serving the bleeder platform located 206 feet above grade.

The four vertical offtakes of each furnace are each 5 feet-9 inches in internal diameter, and are connected in pairs to two 7-foot inside diameter risers connected to the downcomer. On top of the two 7-foot risers and the downcomer are mounted three 30-inch bleeder valves. Each furnace has a single downcomer with an inside diameter of 9 feet. All of these mains are fabricated by welding from ½-inch steel plate, and their bends, and inclined surfaces are lined with ½-inch thick 0.6 per cent carbon steel wearing plates. Connections of the offtakes with the furnace top cones are elliptical in form to increase offtake area.

An automatic centralized lubricating system has been provided for the top machinery, whereby bearings are greased at intervals determined by the setting of an automatic timer controlling a motor-operated grease pump. Two automatic stock-line recorders and one manually operated rod for determining stock-line position are provided for each furnace.

Charging equipment — The skip bridge for each furnace is supported at its lower end on the foundations of the skip pit, and at its upper end on the furnace stack. Both supports are through pin connections. The bridge is of the through-truss type with double track. Total length of skip travel is 224 feet, the skip track being at an angle of 55 degrees-28 minutes with the horizontal. A 5/16-inch steel deck plate encloses the underside of the incline.

Two bail-type skip cars operate on the bridge of each furnace, each car having a capacity of 300 cubic feet and weighing 19,000 pounds empty. Each hoist consists of a single drum, grooved to receive two pairs of ropes, one pair winding over and the other pair winding under. Two 212-horsepower motors drive each hoist. With a maximum load of 40,000 pounds, a car can be hoisted at a speed of 350 feet per minute. Either hoist motor can handle the full load at a somewhat reduced speed.

The skip hoist is installed in the hoist house, which also contains the bell hoists, automatic stock-line recorders and motor-generator sets. The control is a combination of variable voltage and motor field control. Each hoist house is equipped with an air conditioning unit to maintain clean, comfortable working conditions in all weather. Outside air entering the building is cleaned by rotoclones and electrostatic precipitators. Positive air pressure is maintained in each building to prevent infiltration of dirt.

Bell hoists for the furnaces are of the pneumatic type, using regulated 15 psi air obtained from either the cold-blast main or from plant compressed-air lines. The large bell air cylinder hoists have relief valves on each side to permit movement under extreme shock and compensate for between-bell explosions.

Stoves — Each furnace is supplied with hot blast by three two-pass side combustion stoves. These stoves are each 26 feet in diameter and 123½ feet high. The combustion chamber is approximately elliptical, and 56 square feet in cross-sectional area. It is built with a 9-inch skin wall of semi-silica brick laid in high-temperature cement.

Checkers have 1 5/16 inch square openings with 1¼ inch walls. Total heating surface per stove is 250,000 square feet. The checkers are supported on grids cast from special alloy iron. Girders supporting the grids are cast from a high-strength chromium-nickel-molybdenum iron. The ordinary cast-iron columns on which these girders rest stand on a 15-inch thick pad of refractory concrete made with heat-resisting cement and

The last block of the lower inner side wall ring of carbon blocks is being laid in the hearth lining. The carbon block floor had been completely laid and joints rammed before construction of the side walls began.

reinforced with steel bars. The dome brickwork is supported by the stove shell independently of the ring wall. Each stove shell is electrically welded.

Each stove is equipped with a 25,000 cfm blast furnace gas burner, having gas-air ratio controls. Combustion air is furnished by a motor-driven fan. Burners are located on a stove operating platform at the same level as the cast house floor.

The hot blast valves are 48 inch mushroom type. The cold blast main at the stoves is 4 feet-6 inches diameter and contains a 48-inch snort valve. The cold blast connection from the main to each stove is 42 inches in diameter and contains a 42-inch valve. A 36-inch mixer pipe header extends from the cold blast main and is connected to the bottom of each hot blast valve trunk, by means of a 30-inch pipe containing a 28-inch valve. The mixer pipe is provided with a 36-inch butterfly valve which is automatically operated.

Dustcatchers — The dustcatcher for each furnace is 38 feet in diameter with a 40 foot straight side. Shells are of welded construction, insulated on the outside with a 2-inch thickness of magnesia block, weatherproofed by asbestos sheets.

Gas from the single downcomer of each furnace enters the center of the top cone of the dustcatcher and passes through an expanding nozzle, having an included angle of 13½ degrees, extending vertically downward into the dustcatcher. Gas flow changes its direction at the bottom of the nozzle to pass upward and out of the dustcatcher through an annular passage around the nozzle. Dust eliminated from the gas stream accumulates in the bottom cone of the dustcatcher and is withdrawn through a pug mill.

Gas from the dustcatchers is collected in a common main leading to three primary gas washers having superimposed electrostatic precipitators. Each primary washer is 21 feet-0 inches in diameter with a 65 foot-0 inches straight side and contains four banks of tile and two groups of water spray nozzles. The lowest bank of tile consists of four courses of 6 inch diameter by 6 inch ong partition rings. Above this bank is a group of 32 spray nozzles. The other three banks each consist of eight courses of 4½ inches high drip point grid tile. Above the top bank is the second group of spray nozzles. Each precipitator contains 224 tubes, 12 inches in diameter, and 15 feet-0 inches long.

Pump house and precipitator substation — The pump house and precipitator substation is a two story steel frame brick building 32 feet-0 inches wide and 66 feet-0 inches long. The first floor is at ground level and contains three 5100 gpm gas washer pumps, two 1000 gpm precipitator spray and flushing pumps, one 4000 gpm cinder granulating pump, and one 20 gpm bell spray pump. The second floor contains the switchgear for the pump motors and other equipment, a room for the gas washer and precipitator valves, a room for the precipitator substation equipment, and a battery room.

Adjacent to the pump house is a sump and pump suction well to receive the furnace cooling water, which is pumped to the washers.

Granulated cinder tank — The granulated cinder tank is a reinforced concrete pit 60 feet-0 inches wide and 121 feet-0 inches long, the top of which is at ground level. A loading track extends over the pit along each of the two side walls. From the common cinder runner, which parallels one end of the tank, 3 spouts extend to the tank. At the opposite end are 2 rotary screens for screening the water leaving the tank and entering the sewer. Over the pit is a crane runway carrying a 10-ton electric traveling crane, 65 feet-0 inches span, equipped with a 4 cubic yard grab bucket.

Stockhouse — The stockhouse is a steel structure supporting two rows of bins, on top of which are three standard gage tracks, and underneath which is a brick enclosure having a concrete floor and a standard gage track. For each furnace there are seven ore bins with a total capacity of 1600 tons, two limestone bins with a total capacity of 340 tons, eight coke bins with a total capacity of 490 tons, and three miscellaneous material, and one scrap bin with a total volume of 11,000 cubic feet. The ore, stone, scrap, and miscellaneous material bins are equipped with manually operated quadrant gates. A 40-ton capacity scale car transfers these materials from the bins to the skip cars. Coke handling is entirely automatic for normal operation, but arranged for manual control in emergencies. Coke screens are being installed at only one furnace for the present, the second furnace being arranged for the installation of the screens in the future. The eight coke bins and handling facilities are grouped symmetrically about the furnace and skip pit center line. Three bins on each side of the skip pit are equipped with vibrating feeders which feed the coke on to a 60-inch wide conveyor, which in turn carries it to a 6 feet × 10 feet, single deck vibrating screen. From the screen the coke is discharged into a 275 cubic foot capacity weight hopper having an air operated hinged plate gate, and thence to the skip car. The two bins adjacent to the skip pit center line are equipped with air operated sliding gates through which the coke is chuted to the weight hopper, by-passing the screen.

An automatic stock watering system is provided, consisting of a 200 gallon tank, complete with electrodes, for measuring quantities of water from 20 gallons to 200

gallons in 20 gallon increments, and the necessary solenoid valves and piping.

The skip pit is provided with a motor operated clean-up hoist, having a six cubic foot car.

Cast house — Each furnace has a cast house of steel construction, 58 feet wide and extending out 140 feet from the furnace center line, containing a 25-ton electric overhead traveling crane of 58 foot span, equipped with a single hook, and a hook-on type one cubic yard capacity single line grab bucket. Iron runners are provided for directing the iron to eight 75-ton capacity ladles. The cinder runners from the two cinder notches, which are 72 degrees apart, join into a single runner extending to the cinder granulating tank. A cinder runner is also provided for directing the cinder into five ladles during emergencies. The floor around the furnace is paved with firebrick, laid on a sand cushion, under which is a reinforced concrete slab supported by steel beams and columns. The remainder of the floor consists of cast iron checkered plates laid on steel beams. That portion of the cinder runner which extends to the ladles is adjacent to the outside of the building columns and is provided with a brick paved platform which is parallel to and extends out from the building 13 feet-8 inches. A portion of the roof adjacent to the furnace is removable to permit handling of the large bell and hopper through the cast house.

The clay gun is an electric, two-motor type gun, with a 12 cubic foot capacity barrel. The operating station and control room is a brick wall enclosure, 12 feet by 20 feet, located a short distance from the furnace. Reinforced concrete storage bins are provided for sand, clay, coke breeze, and scrap, on the cast house floor.

Four railroad tracks serve the cast house, two for iron ladles, one for cinder ladles, and one for materials.

THE REDESIGN OF A DIRECT FIRED AIR HEATER

. . . . this paper, winner of one of the 1947 James F. Lincoln Arc Welding Foundation awards, suggests possible uses for welded stainless steel assemblies in furnace design . .

By R. M. RUSH, H. A. PIETSCH, and D. H. MARLIN

Dravo Corporation

Pittsburgh, Pennsylvania

▲ UNIT heaters have replaced steam radiation for industrial heating almost universally in the last 25 years. Not only were they less costly, but they directed the heated air in such a way that more even temperatures prevailed throughout the building. With wall radiation the heat rose to the ceiling causing temperature differences of 30 to 40 F between working level and high roofs. Unit heaters which took the cool air from the floor, discharging horizontally at high velocity, tended to keep the heat more nearly in the working levels and reduced fuel bills by lessening roof heat losses. Steam unit heaters of this type are well known and where steam in sufficient quantities is available, are fully adequate for a normal heating job.

Assuming, however, that steam is not already available, the cost of a boiler plant for heating alone becomes almost prohibitive, especially in these days of high labor and material costs. In addition, firemen are required 8 months of the year, 24 hours a day, seven days a week. The labor cost for firemen frequently exceeded the cost for fuel. Direct-fired unit heaters in which fuel is piped directly to the unit instead of steam, offers thus, opportunities not only to save capital charges for the cost of a boiler plant, but also annual fireman payroll costs for the life of the plant. Suspended gas fired heaters have been extensively used for some time, and are satisfactory for small commercial or industrial buildings when gas is plentiful. Until recent years, there was not available, however, a large floor type direct-fired heater suitable for either gas or oil. In order to satisfy a well defined demand for such a unit, designs were completed and tests indicated quite satisfactory performances. The main feature was a corrugated carbon steel combustion chamber with a multiplicity of fins and deflectors welded on its outer surface. In the prewar days of less costly and more efficient labor, this construction was quite practical. Many improvements were incorporated at about the start of the war and several thousand such heaters were sold. They were used extensively in hangars and war production plants. During the last years of the war, however, the cost of labor increased so much that a redesign was necessary.

The basic change decided upon was to use stainless steel in the welded combustion chamber instead of carbon steel, permitting operation at higher metal temperatures in the heating surfaces resulting in:

1. Need for much less heating surface.
2. Elimination of refractory furnace lining due to higher metal temperatures.
3. Reduction in size and weight of heater thus saving floor space, handling labor, and freight charges.
4. Reduction of labor of fabrication and assembly due to elimination of corrugations, fins and deflectors.
5. Greater margin of safety in respect to oxidation of heating surface.
6. Resistance to corrosion and rust when not in use.
7. Ability to make process type heaters for very high air temperatures.
8. Less resistance of air flow through heater, requiring

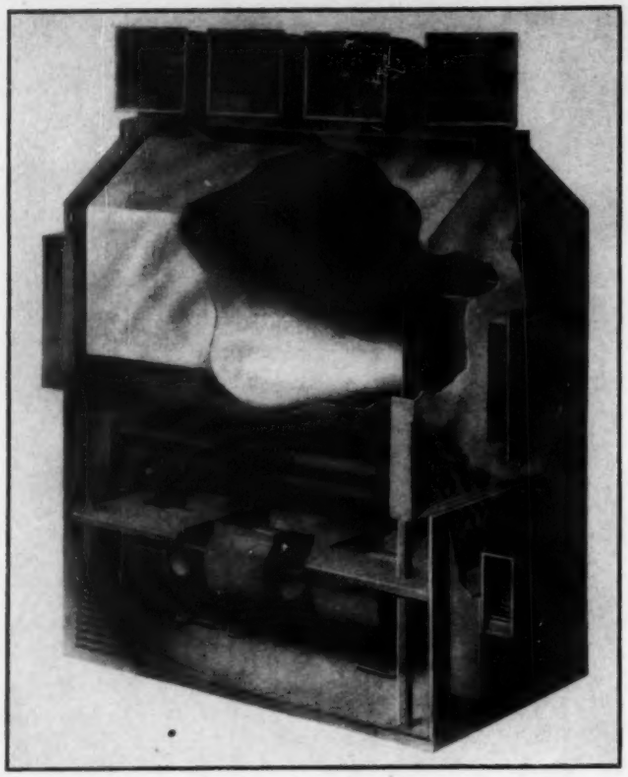


Figure 1 — Cutaway view of heater shows fans, economizer tubes, and stainless steel combustion chamber.

less motor horsepower for the same quantity of air, or more air for the same horsepower.

Comparatively, little information was available concerning stainless steel in similar usage. The properties of stainless steel under high temperatures are well known, and no particular problem was involved in choosing a suitable type. In the front of the combustion chamber, gas temperatures are low enough in the flue passages conducting gases to the tube bank so that ordinary carbon steel could safely be used. The problem then resolved itself to one of welding these steels of entirely different characteristics, (including coefficient of expansion) into a durable, safe, gas-tight chamber, with ordinary qualified welders such as are employed in the normal sheet metal shop. The type of welding rod chosen, and the methods employed are described in the final portion of this paper.

The basic design of both the new and old heaters are the same, consisting of a heat exchanger, enclosed in an outer casing, with fans located in the base to pull cool air from the floor level and propel it over the heating surface. The heating surface consists of a combustion section and an economizer section of tubes. An exhaust fan to pull the products of combustion from the tube bank to atmosphere is mounted on the same shaft as the fans which blow the air over the heating surface. The flame and gases pass four times across the path of the air being heated, in true counter-flow fashion, and high efficiency of fuel utilization results.

Stainless steel was selected to replace the low carbon steel because of its ability to resist oxidation at much higher temperatures. This permitted higher operating temperatures on the steel, and in turn, higher heat transfer per sq ft from the flame and gases through the steel to the air being heated. The higher steel temperature also permitted the burning of gas and oil in the unlined stainless steel chamber. The design of the combustion chamber is such that at the rate of heat transfer obtained, the steel temperatures are well above the end point temperatures of the fuels. Thus, the flame and gases are not cooled to a point where carbon is formed. The unlined chamber permits greater heat transfer due to its entire surface being exposed directly to the flame and gases. Since the heat transfer is greater, the total heating surfaces required is much less, thus saving space, material and cost of labor. The savings in weight and heating surface of the two heat exchanges are as follows:

	Weight of combustion chamber	Per cent savings	Total heating surface	Per cent savings
Low carbon steel unit	1835	....	178	....
Stainless steel unit	335	81.7	84	53

The unit is designed to obtain true "counterflo" heat transfer on both gas and air sides of the unit. The coldest air passes over the coolest gases and the jet type flame is thrown to the rear of the combustion chamber where it curls up toward the top of the chamber and the gases are drawn back to the burner end and pulled out by way of the exhaust flues into the economizer tubes. See Figure 1. All the requirements of good combustion are obtained in the stainless steel heater. They are exact amount of air for combustion, high temperatures for combustion, proper mixture of fuel and air and sufficient time to complete combustion.

The controls are placed neatly in the large control box and the interconnected wiring is braided. The louvered grills were designed to permit the necessary air flow into the base of the unit but at the same time not permitting the viewing of the motor, fans, drives, etc., in the base of the unit which could be seen with the screens of the low carbon steel type. The specially designed oil burner, which is described elsewhere, has also greatly improved the appearance of the heaters.

The base plate of the new design offered an entirely new type of motor base. The motor is simply hinged on its two side lugs by means of a rod and 2 lugs welded to the base plate. The motor weight keeps the right tension on the belts at all times and eliminates the necessity of making up the belts periodically as was necessary on the old type. Attention and maintenance have been drastically reduced.

An oil burner was especially designed for the new heater. Air for combustion was taken under pressure from the main supply fans and introduced tangentially into the oil burner tube which created a swirling action of the air into the atomized oil, resulting in intimate mixture of the fuel and air and a hot jet-like flame. Better performance in the burning of the fuel was the result, compared to the conventional type of burner which was used on the old style unit. The appearance of the new unit is much better with the burner engineered to and for the unit than with the conventional type of burner protruding from the face of the heater. The burner fuel oil pump is located in the base of the

unit where it is out of the way and prevents unauthorized persons from tampering with it.

Due to the elimination of the refractory, maintenance on the new type heater is negligible. This design feature of the new unit makes it more flexible than the old style unit. The new heater can be inverted and suspended or laid horizontally with practically no changes and the unit will function and operate equally as well as in the upright position. Due to its much lesser weight, the support required for these installations is much less costly. In most cases, they can be hung in the trusses of buildings without increasing the supporting members.

The fabrication of the stainless steel unit has been greatly simplified. The number of principal operations to fabricate have been cut to 67 compared to 95 which were necessary on the low carbon steel type. The welding required has been reduced to 186 lineal feet from 400 lineal feet. It is realized that the welding of the stainless steel is more specialized, however, the welders in the shop have increased their efficiency and know-how on the welding of this material so that they are handling stainless steel almost as fast as low carbon steel.

The operational performance of the new stainless steel heater was as good, and most cases better, than the performance of the old style heater. Due to the unrestricted air flow (compared to the finned, restricted air flow on the old style heater) the pressure drop through the unit was greatly reduced.

The heat transfer in the new stainless steel heater is practically instantaneous since there is no refractory to heat up. Conversely, on the shutting down of the unit, it cools almost instantaneously since the heat storage is negligible. This aids in the life of the unit, since the old style unit was vulnerable to the danger of someone shutting off the fans shortly after the burner went off. The maximum temperature recorded on the stainless steel combustion chamber was 1200 F. The type of stainless steel used resists oxidation up to 1650 F. The temperature of the low carbon steel combustion chamber was approximately 700 F. The rapid oxidation point of low carbon steel is approximately 900 F. Therefore, there is a greater margin of safety due to this greater temperature differential in the new heater than in the old design.

Actual performance tests showed efficiences on the old style heater on oil firing of 80 to 83 per cent. The new design ranges from 82.5 to 85.5 per cent and is thus slightly higher.

The change of design to the new unit fostered many new problems in the welding operations and afforded many economies in production. The new unit is largely welded, and with the exception of the combustion chamber, welding techniques used on the older style unit were adaptable to the new design.

Framing members, economizer tubes, motor and fan bases, outer casing, and gas tight flues are welded with the manual metallic arc process. Experience revealed that AWS Class E6013 electrode operated on direct current, straight polarity was the most versatile electrode for use in obtaining an optimum balance of economy and quality.

Resistance welding was successfully applied to accessory parts of the unit. Spot welding, using conventional 90 kva equipment, is used on discharge air nozzles and accessory control boxes. Similarly, ½ in. stud bolts, used for attaching tube cover plates and burner mounting plates, are welded to framing members with a portable stud welding gun operated with d-c welding generators.

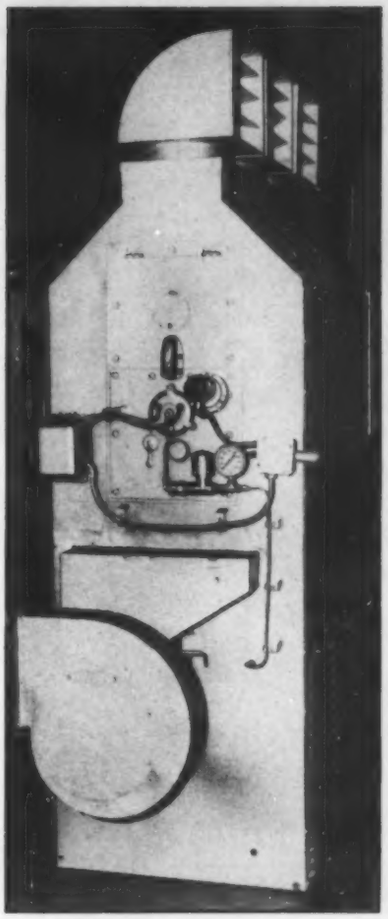


Figure 2 — This view of the heater illustrates access door, oil burner, and exhaust fan.

The all-welded combustion chamber fabricated from heat resisting steel presented new problems involving the metallurgy, operating techniques and quality control of the welded joints. The chamber is fabricated as a unit in pre-assembly and welded to the previously fabricated frame. This unit is made from two types of heat resisting or "stainless" steels.

In order to attain maximum quality of the joints, it was necessary to choose the correct type of electrode coating. The two common types of stainless electrode coatings, namely, the lime type and the titania type, have different molten slag characteristics. This, in turn, has great effect on the operating characteristics of the electrode, as well as the contour and quality of resulting weld.

In general, stainless steel electrodes have lower melting points than the mild steel and hence are more fluid. This, in turn, results in less "penetration" than that experienced with equal diameter mild steel electrodes. However, it has been determined that these joints required no edge preparation other than square shearing when proper welding techniques are employed. The lime type coating has a more viscuous slag than the titania type, and results in greater penetration and less tendency for slag entrapment. Dimensions of the larger

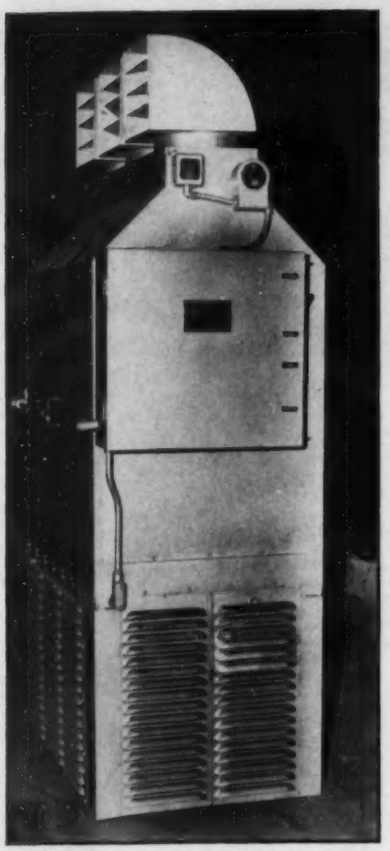


Figure 3—Discharge nozzles, control box, and inlet air louvres in base are shown in photo.

model combustion chambers prevent positioning of all welds, and it has been found that the lime type coating consistently gives better penetration and cleaner welds in the vertical and overhead positions. Better appearance and ease of slag removal (characteristic of titania coatings) are sacrificed for the better quality experienced with the lime type coating.

Similarly, the weld penetration is dependent on diameter of electrode. $\frac{3}{32}$ in. diam electrodes are used for optimum results. Tests have shown that while larger size electrodes give slightly higher welding speeds, the resulting joint lacks sufficient penetration.

The change to these highly alloyed steels involved other operating problems other than primary welding procedures and techniques. More careful handling and storage was necessary because of the increased tendency for "stainless" type electrodes to deteriorate from atmospheric moisture pick-up.

It is readily apparent that the use of these heat resisting steels affords a great simplification of design and resulting reduction of fabrication costs. The elimination of plate corrugations and the accompanying decrease in weld footage reduces the preliminary shaping operations to straight shearing and simple press brake forming. The unit is fabricated from 4 basic parts: two sides and bottom sections, a back plate and a front plate. In the larger models, each side-bottom section is made of two plates since dimensions are in excess of available mill widths.

In conclusion, savings include the following:

1. Greatly reduced freight charges due to lower weights.
2. Floor space savings.
3. Less handling charges, rigging, etc.
4. Less fuel on account of higher efficiency.
5. Less maintenance on account of absence of refractory and use of corrosion resisting stainless steel.
6. Increased production enabling prices to be maintained without increase in spite of higher labor and material costs.

In this paper, we have attempted to tell the story of a redesign employing the arc welding of stainless steel, to relieve a situation that arose from the increasing costs of labor and its decreasing efficiency which threatened to make it necessary to discontinue a previously profitable line of manufacture. The far reaching results are hard to measure.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC. OF

IRON AND STEEL ENGINEER

(Required by the Acts of Congress of August 24, 1912, March 3, 1933 and July 2, 1946)

Name of Publication: *Iron and Steel Engineer*, published monthly at Pittsburgh, Pennsylvania. (Report of October 1, 1947.)

State of Pennsylvania

County of Allegheny

Before me, a notary public in and for the State and county aforesaid, personally appeared T. J. Ess, who, having been duly sworn according to law, deposes and says that he is the editor of the *Iron and Steel Engineer* and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Acts of March 3, 1933 and July 2, 1946, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher: Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh Pennsylvania.

Editor: T. J. Ess, 1010 Empire Building, Pittsburgh. Pennsylvania.

Managing Editor: None.

Business Manager: None.

2. That the owner is: Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh, Pennsylvania.

No stockholders.

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1947

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J. H. Strassburger, *Manager, Service and Maintenance*, Weirton Steel Company, Weirton, West Virginia.

John L. Young, *Vice President, Charge of Engineering*, National Tube Company, Pittsburgh, Pennsylvania.

C. E. Pritchard, *Lubrication Engineer*, Republic Steel Corporation, Cleveland, Ohio.

John B. Mitchell, *Vice President in charge of Manufacturing Operations*, Jones & Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

T. J. ESS, Editor.

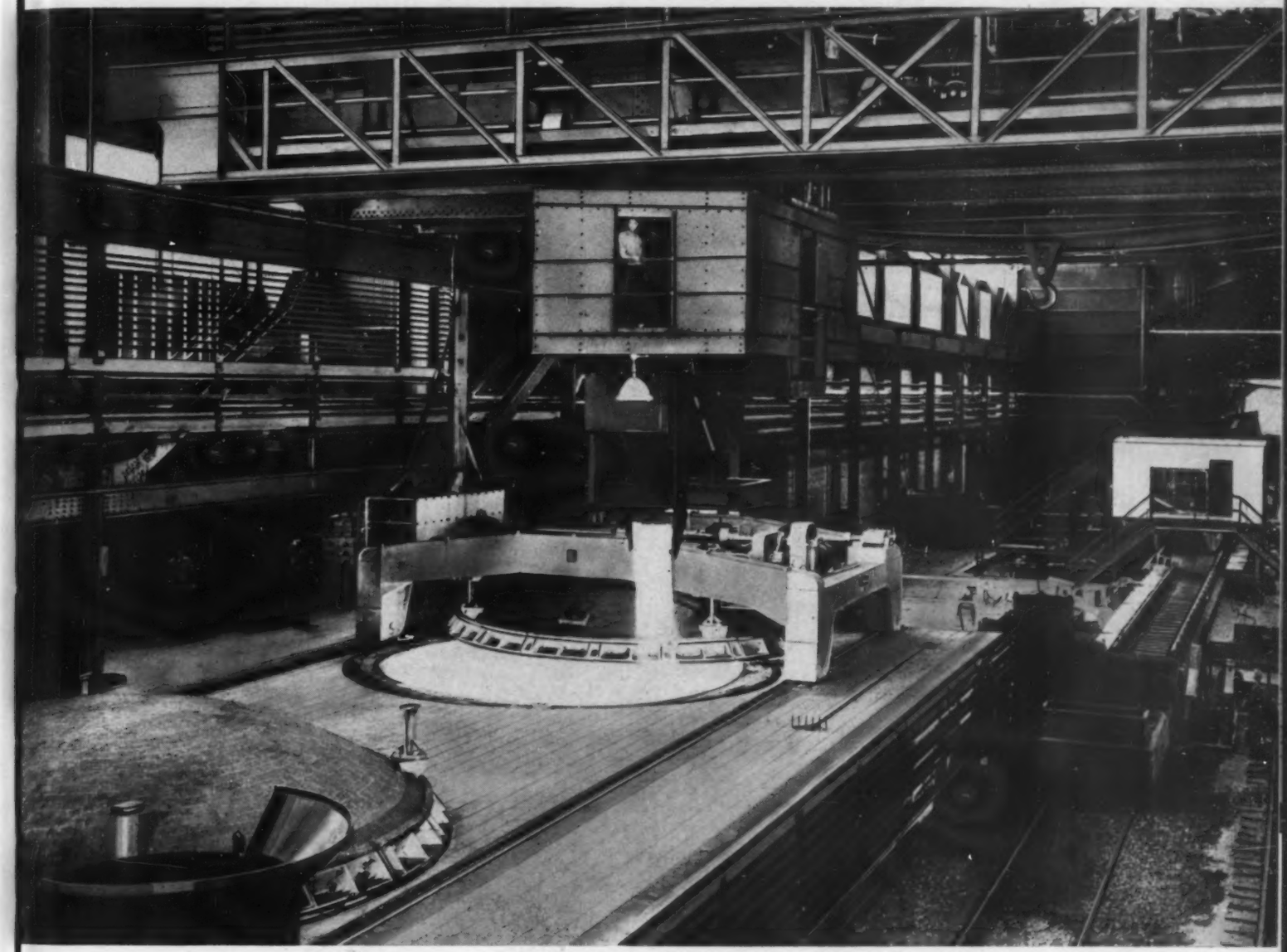
Sworn to and subscribed before me this 19th day of September, 1947.

G. WILLIAM JONES, Jr., Notary Public.

(My commission expires February 9, 1951.)

BUILT BY MORGAN Engineering

MORGAN 7½-TON, 81′3″ SPAN SOAKING PIT CRANE



Illustrated is a Morgan 7½-Ton, 6-Motor, 81′3″ Span, Stiff Leg Type Soaking Pit Crane. It serves a Morgan 36″ Two-High Blooming Mill which was furnished complete with auxiliary equipment. It is equipped with fabricated welded trolley and bridge trucks. Morgan Pit Cranes are provided with spur or worm gear operated trolleys and sleeve or anti-friction bearings as required.

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO. 1420 Oliver Building, Pittsburgh

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

Get Greater Use from Switches and Panelboards by Installing FUSETRONS

Here's Proof That It Can Be Done

"Fusetrons Saved Us the Cost and Trouble of Rebuilding Our Dust Tight Switch Room"

"Last year when we remodeled our mill and constructed a sizeable addition, we ran into a very serious problem. When this work was laid out, the specifications called for reduced voltage starters which would have permitted us to use 200 ampere, 575 volt switches. The orders for the material were placed and the 200 ampere switches promptly received. But we were told that the delivery on reduced voltage starters would be many months away.

"Reasonably prompt delivery could have been had on across-the-line starters but such starters would have required 400 amp. switches that were too large to fit in our dust tight room.

"Through the use of 200 ampere Fusetrons, instead of ordinary fuses, it was possible to use the 200 ampere switches. This saved us the cost and inconvenience of rebuilding our dust tight room and we believe gives us better protection than we would have had with the installation as originally planned."

DOUGHBOY INDUSTRIES, INC., Milling Division
New Richmond, Wisconsin

E. J. Cashman, President

What is a FUSETRON?

The Fusetron is a DUAL element device — a Fuse to which is added a Thermal cutout.

The result is a fuse with tremendous time-lag and much less electrical resistance.

Fusetrons have the same degree of Underwriters' Laboratory approval for both motor-running and circuit protection as the most expensive devices made.

Made to the same dimensions as ordinary fuses, Fusetrons fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 ampere in both 250 and 600 volt types. Also in tamper-resisting type (Fustata) for 125 volt circuits.

Their cost is surprisingly low.

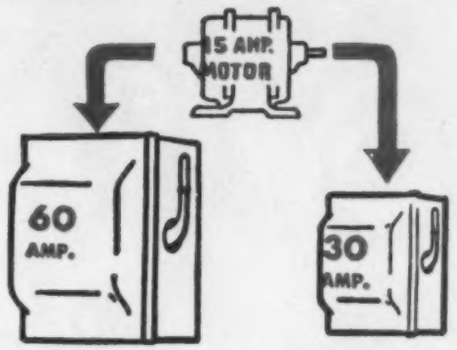
BUSS

SAVE SPACE.. SAVE MONEY *Get Better Protection*

On motor circuits Fusetrons can be used in sizes near to the operating load. That cannot be done with ordinary fuses. It is possible with Fusetrons because they have a tremendous time-lag that prevents them from opening on starting currents or other harmless overloads.

This means that on motor circuits, where Fusetrons are used in the same size as ordinary fuses, more motors or a larger motor can generally be used on the circuit without it being necessary to install a larger switch or panel . . . or for any given load on the circuit, Fusetrons in sizes smaller than ordinary fuses can be used.

For Example:
Take a 15 ampere AC motor on a normal installation.



OVERSIZE

With ordinary fuses, 45 amp. fuses in a 60 ampere switch must be used. The OVERSIZE fuses and switch are necessary to prevent needless blowing on the motor starting current — and you get only short-circuit protection for the circuit.

PROPER SIZE

With Fusetrons you use the PROPER size to give both motor-running and short-circuit protection — or 15 ampere Fusetrons in a 30 ampere switch.

Consider These Advantages of Fusetrons over other Protective Devices

On NEW Installations of Motor Circuits

- Save space because PROPER size Fusetrons permit using PROPER size Switches and Panelboards instead of OVERSIZE.
- More convenient location of switches and panelboards are often possible because of smaller sizes required.
- Save money on fuse replacement costs. By eliminating blowing on starting currents or other harmless overloads, fewer Fusetrons are needed than when fuses are used.

On PRESENT Motor Circuits

- Increase size of motor, or add motors to a circuit without installing a new switch or panelboard. Fusetrons permit a great increase in the actual running load on switch or panel.
- Save cost and trouble of tearing out present switch or panel by replacing fuses with Fusetrons.
- Get fuller use from every switch or panel by using Fusetrons.

Get Many Kinds of Protection Heretofore Not Available by Installing Fusetrons Throughout the Electrical System

✱ Entirely wipe out needless blows caused by motor starting currents or other harmless overloads. ✱ Give Thermal Protection to Panelboards and Switches. ✱ Prevent needless blows caused by heating in panels and switches. ✱ Permit use of larger motor or adding more motors on circuit without installing larger switch or panel. ✱ On new installations, proper size switches and panels can be used instead of oversize. ✱ Protect motors against burnout. ✱ Give double burnout protection to large motors at little or no extra cost. ✱ Provide simplest way to stop burnouts from single phasing. ✱ Make burnout protection of small motors simple and inexpensive. ✱ Protect coils, transformers, solenoids against burn-out.

Get All the Facts

Get Better Protection — Send the Coupon Now

Even one lost motor or one needless shutdown or one destroyed panel may cost you more than replacing every fuse with a Fusetron. Don't risk such losses, change over the whole plant to Fusetrons.

FUSETRONS
SOLD THROUGH WHOLESALERS

Bussmann Mfg. Co., University at Jefferson
St. Louis 7, Mo. (Division McGraw Electric Co.)

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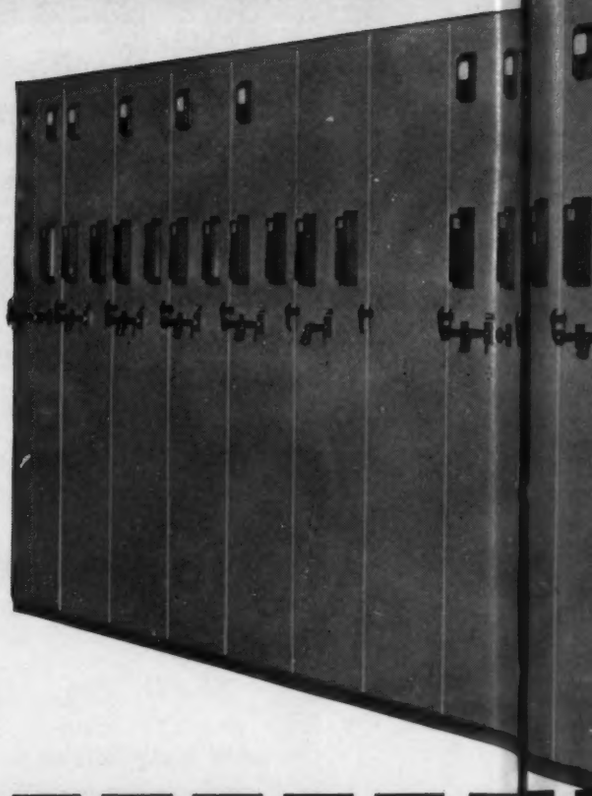
Install *AIR BLAST* Metal-Clad

PLAY IT SAFE!



Guard Against Damage to Valuable Mill Equipment • Protect Rolling Mill Motors by Rapid Clearing of Faults • Provide Complete Safety for Your Men • Install Factory-Built, Factory-Wired Allis-Chalmers Metal-Clad Switchgear with *Air Blast* Circuit Breakers!

THIS IS THE *ONLY* DRAWOUT VERTICAL LIFT METAL-CLAD SWITCHGEAR equipped with *Air Blast* circuit breakers! That means a space-saving lineup of switchgear that is easily inspected and maintained . . . centralizes power control . . . protects personnel . . . and reduces potential fire hazards.

Drawout construction permits ready access to circuit breakers during inspection and maintenance—and interrupting with air blast reduces arcing time to less than a cycle insuring long contact life. *Air Blast* breakers are mechanically strong to withstand repeated "closing-opening" operations. *They consistently complete interruption within four to five cycles!* These 7.5 and 15 kv units have interrupting capacities of 250,000 and 500,000 kva.

For more information, contact your nearby A-C office, or write for *new* bulletin 18B6760. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

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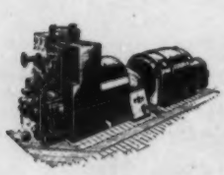

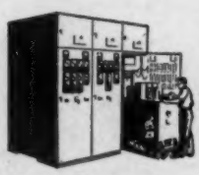

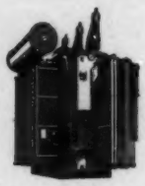

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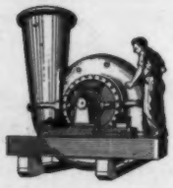
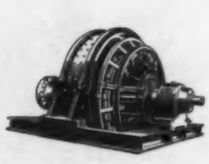
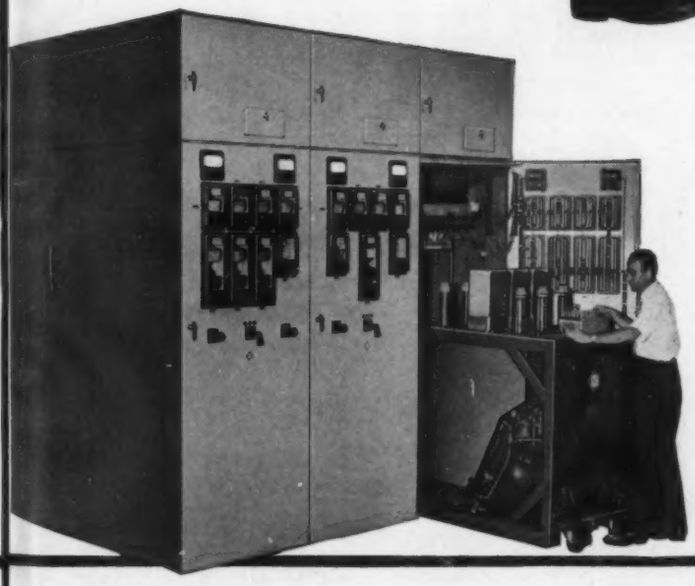




UTILIZATION & PROCESS — Motors, Blowers, Rectifiers, M-G Sets, Betatron, Pumps, Compressors, *Regulex* Exciters, *Texrope* V-Belt Drives . . .

Switchgear and...



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LOWER BREAKER to floor by means of electrically operated motor-lift . . . pull it from structure . . . and roll it away to convenient test stand—that's all it takes! Breaker cannot be lowered when in the closed position because of positive interlocks . . . and automatic shutters prevent accidental contact with live parts—that's added safety for personnel during inspection and maintenance!

A 2360

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Model 244

Model 987 POWERLUBER
Air-motor operated, High-Pressure Grease Gun. 60-lb. capacity. Truck available for easy portability.

Model 1273D PORTO-PAK
High-Pressure Grease Gun. Has automatic Pressure Release. 30-lb. capacity.

TRANSFER PUMP Model 1316
Heavy-Duty Pump — Handles heavy and viscous lubricants.

REDUCE Down Time--INCREASE Production with LINCOLN *Engineered* LUBRICATING EQUIPMENT

The finest lubricants available will not protect bearings against failure unless they are properly applied. Good lubricants applied to bearing surfaces with Lincoln High-Pressure Lubricating Equipment will assure longer bearing life, reduce down-time and increase production.

No matter what your lubrication needs may be — from grease fittings to a complete, full-automatic, centralized lubricating system, Lincoln can furnish the *Right* equipment specifically engineered to do the job. Ask your Wholesaler for information on the complete line of Lincoln Lubricating Systems, or write us direct.

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One-hand operation. All steel. Capacity 9 ozs. Also available with 15 oz. capacity.

Model 1035
Heavy Duty LEVER GUN
Develops 10,000 lbs. pressure. 19 ounce capacity.

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Complete range of types and sizes.

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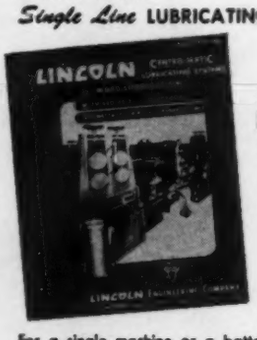
HEAVY DUTY 4" SERIES Airline* Drum Pumps

Model 1793

Model 1799

Models available with various pressure ratios to fit 400 lb. and 100 lb. size drums of either bung-opening or full-open type. Two wheel truck for 100 lb. Models.

CENTRO-MATIC *Single Line* LUBRICATING SYSTEMS



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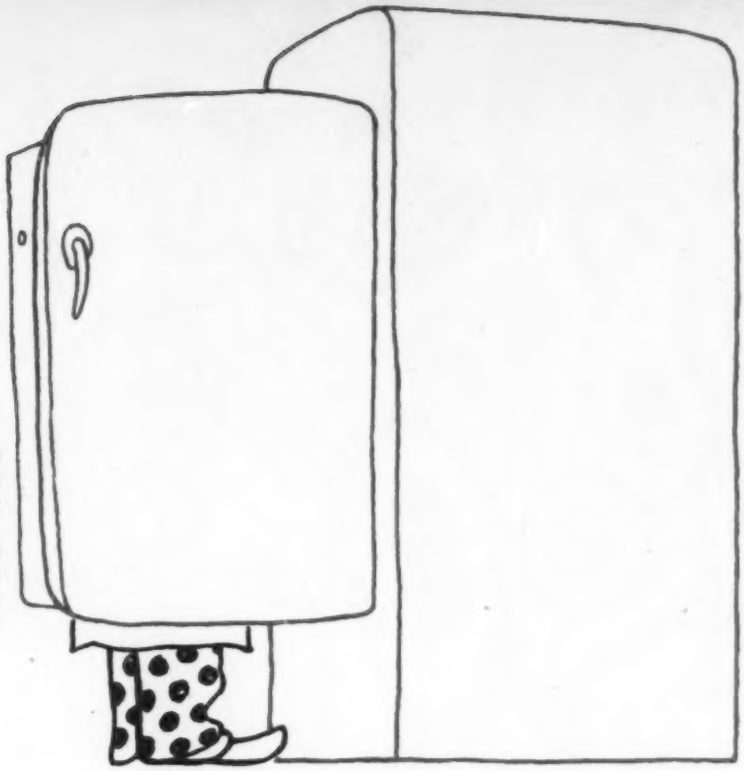
MILLIONS OF REFRIGERATORS and other appliances which Americans will buy this year and every year account for thousands upon thousands of the tons of iron and steel which keep American iron and steel mills rolling along in seemingly endless production.



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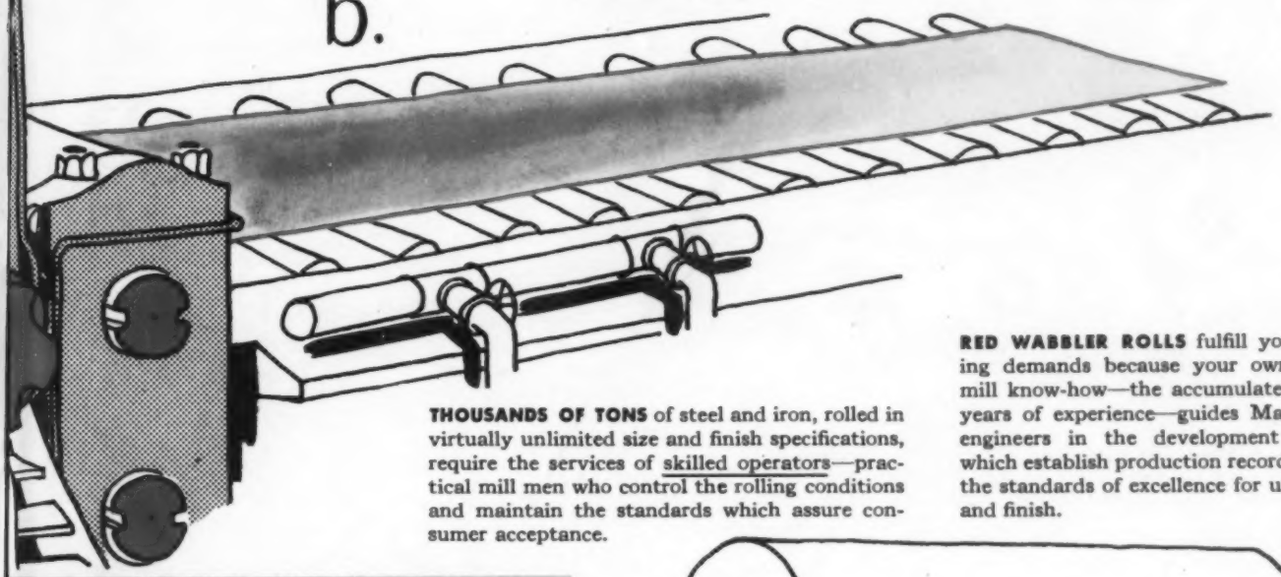
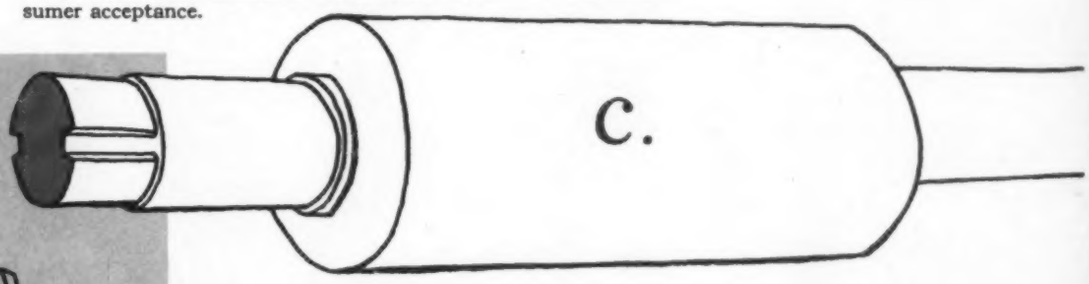


THOUSANDS OF TONS of steel and iron, rolled in virtually unlimited size and finish specifications, require the services of skilled operators—practical mill men who control the rolling conditions and maintain the standards which assure consumer acceptance.

RED WABBLER ROLLS fulfill your exacting demands because your own rolling-mill know-how—the accumulated skill of years of experience—guides Mack-Hemp engineers in the development of rolls which establish production records and set the standards of excellence for uniformity and finish.



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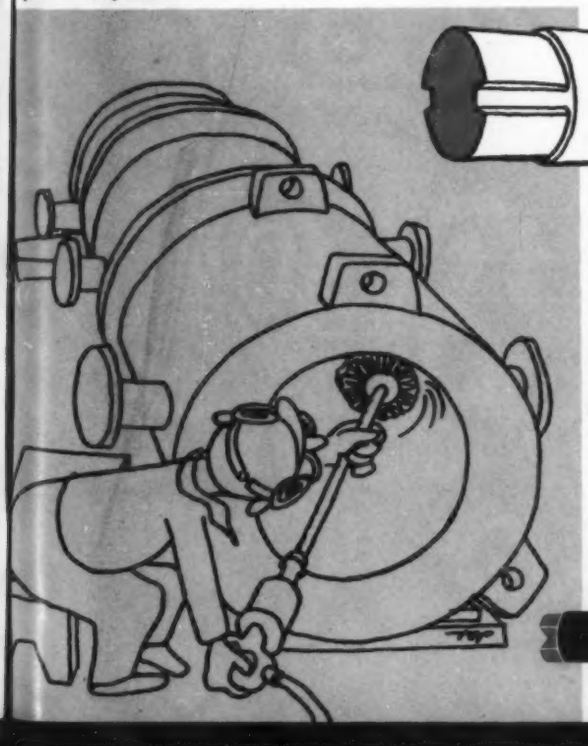

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MACK-HEMP CRAFTSMEN and mill-wise M-H engineers continue to combine their skills to supplement your know-how in the design, metallurgy and manufacture of Red Wabbler Rolls—the proper rolls for your production rolling operations.

MACKINTOSH-HEMPHILL CO.

PITTSBURGH AND MIDLAND, PA.

Makers of the rolls with the red wabblers

R. L. HALL
BIRMINGHAM DISTRICT SECTION

PERCY J. BRITT
BUFFALO DISTRICT SECTION

PAUL E. THOMAS
CHICAGO DISTRICT SECTI

AISE DISTRICT CHAIRMEN 1947-1948

R. L. HALL was graduated from Georgia Tech in 1931 in electrical engineering and has been associated with the Tennessee Coal, Iron and Railroad Company since 1926. In 1936, Mr. Hall was first employed as a co-operative student in the electrical department, Fairfield wire works, and later was transferred to the industrial engineering department. He was transferred, in 1939, to the electrical department, Ensley works, as assistant chief electrician, and at present is superintendent of the mechanical and electrical department, Ensley works.

PERCY J. BRITT was born and educated in Syracuse, New York, where he was graduated from the Christian Brothers Academy (high school). Mr. Britt worked 18 years for Halcomb Steel division, Crucible Steel Company of America, Syracuse, New York, starting as rolling mill clerk, then going to assistant foreman of bar mills, night superintendent, and superintendent of inspection and shipping departments. He then went to the Simonds Saw and Steel Company, Lockport, New York, for six years, as assistant superintendent. In April, 1947, he joined the Wickwire Spencer Steel division, Colorado Fuel and Iron Corporation, as assistant superintendent of industrial relations with his headquarters in Buffalo, New York.

PAUL E. THOMAS, assistant division superintendent of maintenance at Carnegie-Illinois Steel Corporation, Gary steel works, Gary, Indiana, was born in Indiana and graduated from Purdue University's school of electrical engineering in 1927. Mr. Thomas obtained his early steel mill experience working summer vacations at American Sheet and Tin Plate, Elwood, Indiana. He was employed by the Illinois Steel Corporation, Gary, Indiana in 1924 as a wireman and later as an electrical testing engineer, taking leave of absence to finish his senior year at Purdue University. In 1929 he left the steel industry to go with Byllesby Engineering and Management Company as a design engineer and squad boss. From 1932 to 1936 he was employed by the city of Crown Point, Indiana, in charge of construction of a water filteration plant. He again entered the steel industry in 1936 in the employ of Carnegie-Illinois Steel Corporation, Gary steel works, as a design draftsman, design engineer and squad boss. From 1942 to 1944 he was assistant chief engineer and later acting chief engineer for Carnegie-Illinois during the construction and operation of the Gary armor plate plant. After this he was appointed assistant electrical engineer at Gary steel works, later became project engineer and in July, 1947 was appointed to his present position.

JOHN STOUFFER is chief engineer with Republic Steel Corporation in the Youngstown, Ohio, district. Previous to going with Republic Steel Corporation in 1933, Mr. Stouffer was with Inland Steel Company, Arthur G. McKee Company, Koppers Company, and Westinghouse Electric Corporation. He obtained his engineering education at the University of Maryland and Carnegie Institute of Technology.

PHIL E. HAGLUND, upon leaving high school, worked in the laboratory of the Oliver Mining Company for about 8 years, finishing several courses in chemistry in the meantime. In the fall of 1914, he moved to the laboratory of the Semet Solvay Company, in Detroit, Michigan. From the fall of 1915 until the present Mr. Haglund has been with the Ford Motor Company in Detroit and Dearborn, Michigan, serving in numerous metallurgical jobs in both iron and steel. He began in their laboratory from where he was transferred to the foundry and placed on their first electric furnace. The job led to larger and larger furnaces until one was built of 50-ton capacity. For a period of about 8 years he worked on electric furnaces, mostly on experimental and development work. Following this he was in charge of the iron melting department and, for a short while, served as assistant superintendent in the foundry. He left the foundry in 1926 and served as assistant superintendent and superintendent in the open hearth department until 1941. Since then he has had various duties in the field of steel metallurgy and at present is looking after the metallurgical end of making electric furnace rim steel.

WILLIAM N. HORKO was first an electrician with various electrical contractors in Philadelphia until 1921. He went to college preparatory at Brown preparatory evening school 1919-1921 and graduated from Drexel Institute in 1925 with a degree in electrical engineering. Mr. Horko went with General Electric Company and United Engineers and Constructors as an electrical draftsman. He then entered employment of Henry Disston and Sons, Inc., Philadelphia, Pennsylvania, in 1926 as electrical draftsman. In 1930 he was made furnace engineer in charge of all heating and heat treating equipment, which position is held at the present time.

JOHN L. YOUNG is a native of Evansville, Indiana and graduated from the University of Indiana. Mr. Young began his career with Timken Roller Bearing Company in Canton, Ohio, where he held various positions in the alloy tube and steel departments; he later transferred to the metallurgical department. In 1930, Mr. Young went to Pittsburgh for Timken as a development engineer, and later returned to Canton and became assistant general manager of Timken's industrial division.

Mr. Young joined United Engineering and Foundry Company, Pittsburgh, Pennsylvania, in 1936. In 1941, he was loaned as project manager to design and construct the Defense Plant Corporation's aluminum rolling mills at Trentwood, Washington. He was vice president in charge of industrial research and development for United Engineering and Foundry Company, before assuming his present position as vice president in charge of engineering of United States Steel Corporation's National Tube Company in 1945.

JOHN STOUFFER
CLEVELAND DISTRICT SECTION

PHIL E. HAGLUND
DETROIT DISTRICT SECTION

WILLIAM N. HORKO
PHILADELPHIA DISTRICT SECTION

JOHN L. YOUNG
PITTSBURGH DISTRICT SEC

PRODUCT *Information*

ON ANY OF THE PRODUCTS MENTIONED IN THIS ISSUE

Below is an index of products referred to in editorial and advertising pages of this issue. If you desire additional information on any of them, use one of the accompanying postcards in requesting it. In each case give name of product and page number. The information will come to you directly from the manufacturer involved.

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IRON AND STEEL ENGINEER December, 1947

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BETHLEHEM BUILDS QUENCHING CAR FOR INCANDESCENT COKE TRANSPORTATION

▲ A quenching car, with air conditioned cab, and built almost entirely of Mayari R low-alloy, high-strength steel, has recently been placed in operation in the coke works at the Bethlehem, Pennsylvania plant of Bethlehem Steel Company. This car is used for carrying the incandescent coke from the ovens to the quenching tower where it is deluged with water to cool the coke below the combustion temperature before it is placed in storage. Such a service is about as severe as may be found, as it exposes the steel alternately to high temperatures and the action of steam and hot water. To aggravate the condition the water used in the quenching operation is reclaimed from other operations and is highly contaminated by acids and other corrosive chemicals.

As Mayari R has already been found to stand up very well in the corrosive atmosphere of the coke works — in roofing, pipe lines and various structural supports — it is expected that the new car will have a considerably longer life than the conventional car made from mild carbon steel. Normally Mayari R is rated to be four to six times more resistant to atmospheric corrosion than ordinary plain steel.

The operator's cab, made from $\frac{1}{8}$ in. sheets on the outside and $\frac{1}{16}$ in. sheets on the inside, with fibre glass insulation between, is kept at constant temperature by means of a thermostatically controlled air-conditioning unit mounted on an enclosed platform outside the cab. Cold, filtered air is circulated in the summertime, electrically heated air in the cold season.

Overall dimensions and other characteristics of the car are as follows: length, 58 ft 6 in.; width, 13 ft 2 in.; height above rails 11 ft $9\frac{1}{4}$ in.; capacity, 7 tons of coke; net weight 72 tons, of which 52 tons is Mayari R. It is powered by two 75-hp motors and is capable of a maximum speed of about 800 ft per min. The car itself is lined with $\frac{1}{2}$ in. and $\frac{3}{4}$ in. abrasion-resistant manganese steel plate, reinforced with ribs, angles, and channels, and with the floor supported on $1\frac{1}{4}$ in. × 6 in. × 13 ft grid bars. The truck bolsters are made of $1\frac{1}{4}$ in. plates and flats, without any angles or structural shapes, the body bolster of H-beams and channels. Both motors are supported on cross beams mounted on rubber supports, eliminating all springs. Except for a few bolts and clip angles, the car is of all-welded construction.

A second car, similar in design and construction, will be placed in operation in the immediate future. Both cars were fabricated at the Bethlehem plant.

This new car, built almost entirely of low-alloy, high-strength steel, is expected to have considerably longer life than those made from mild carbon steel.

VANDERGRIFT COLD MILL BEGINS OPERATION

▲ An important step forward in satisfying the electrical industry's critical demand for special alloy and silicon steel sheets began at the Vandergrift, Pennsylvania, plant of Carnegie-Illinois Steel Corporation recently when actual rolling com-

menced on this U. S. Steel plant's new 54-in. cold reduction mill. Tune-up operations have been underway on the mill for some time.

Rolling on the mill marks a new era in the Vandergrift plant's steelmaking and finishing activities in producing high grade alloy and electrical steel products. Eventual completion of the improvement program, which includes additional continuous heat-treating and shearing facilities, will contribute materially to the electrical industry's need for special steels to be fabricated into transformers, motors, electrical control equipment, and hundreds of other electrical appliances for domestic and industrial use.

The high speed cold reduction unit is capable of operating at a speed of 1500 fpm, handling coils weighing up to 15,000 lb. Power is furnished by a 3500 hp mill motor and two 1750 hp reel motors. Steel coils now being cold reduced on the new mill are shipped by rail and motor freight from Carnegie-Illinois' continuous hot strip mill at Irvin works, Dravosburg, Pennsylvania.

Approximately 50 offices are provided for those engaged in engineering and research. The exact number is variable since the building is of the modular unit type. An employees cafeteria is located in the penthouse.

AIRCO OPENS APPARATUS RESEARCH LABORATORY

▲ Air Reduction Company's new apparatus research laboratory is located in Murray Hill, New Jersey. The main building is a red brick structure with all-welded steel framework and provides some 78,000 sq ft of floor space. In addition, there are two service buildings: an acetylene generator house and a combination boiler room and garage.

Because of the specialized nature of the research work, most of the laboratory space is serviced with outlets carrying high and low pressure oxygen, acetylene, nitrogen, city gas, compressed air and 440 volts three-phase and 110 volts single-phase electric current, and hot and cold water.

In addition to the main high-ceilinged machine shop and test and assembly area where special experimental machinery and apparatus, and prototypes of production equipment are made, there is another high-ceilinged, especially ventilated flameproof area for conducting experiments in the combustion of gases and processing of metals. There are, also, a number of conventional service laboratories, such as an X-ray room, chemical laboratory, mechanical testing laboratory and metallographic laboratory, plus specially equipped laboratories, including a high pressure oxygen laboratory and a compressed gas cylinder testing laboratory.

One of the newest, and perhaps most important, of the industrial gas applications on which Airco's researchers are busily at work involves the use of oxygen as an aid in the combustion of fuel in steel melting and the control of hot metal analysis. Test work already conducted in the open hearth indicates that the relatively long period involved in melting down steel scrap may be shortened as much as 40 per cent, but final figures will not be available until further experimental work has been completed.

After eighteen months of intensive application in the steel industry, it is obvious that while oxygen is not solving the present steel shortage it has certainly won a high priority in the future thinking of steel plant technologists.

Considerable experimental work is continuing in extending the use of oxygen in the foundry cupola, and in the Bessemer furnace. A tonnage oxygen plant is now being constructed jointly by Air Reduction, Koppers Company, Inc., and Bethlehem Steel Company at Johnstown, Pennsylvania. When completed it will permit accurate determinations of the problems involved in the manufacture of large volumes of low purity oxygen, and in the use of oxygen for the blast furnace production of iron and ferrous alloys.

Another recent application of oxygen in the steel industry involves the cutting of hot blooms and billets. The usual steel mill practice is to cut hot blooms mechanically with a shear. When one considers that every bloom is cropped on both ends several times until sound metal has been reached, and that many blooms are cut into two or three parts after rolling, it becomes readily apparent that the duty of such a shear is quite heavy. The cost of maintenance of the mechanical shears and the cost of the shear blades, which have to be replaced very frequently, is substantial. Furthermore, the initial cost of a hot cut-off shear is in the neighborhood of $100,000. Because of these

Researchers are studying the use of oxygen as an aid in the combustion of fuel in steel melting.

reasons, replacement of hot cut-off shears with oxygen cut-off machines appears to be quite attractive. However, the economy of the substitution is contingent upon the ability to make cuts at speeds approximating those of the shear, and research efforts are directed at speeding up the oxy-acetylene cutting process.

The use of industrial gases for refining metals has advanced rapidly in the past two years. Initial experiments in this field have been made in the steel industry where oxygen is injected into the molten bath of the open hearth to bring about rapid carbon reduction. This results in raising production as much as 25 per cent compared with the slag-metal practice. Already this use of oxygen has become a regular production tool for plants making very low carbon steels. "Flushing" various molten metals with other gases such as nitrogen, helium and argon has been found beneficial in eliminating certain physical defects which might otherwise occur in the solidified product, such as porosity, poor grain structure, brittleness, etc.

Surface imperfections which develop in the casting and subsequent rolling of steel must be removed in order to obtain a quality product. In the case of ordinary steels, this has been done by scarfing, a process which consists of removing a thin layer from the surface of the metal through use of the oxyacetylene flame. Until recently, however, this process was not applicable to the stainless steels because of the refractory nature of the oxides formed and it was necessary to remove defects by chipping and grinding, an expensive and time-consuming measure.

The scarfing of stainless steels has become possible through the use of a flux, which has the property of reducing the melting point of the refractory oxides formed, so that the oxidizing action can be generated. The flux is injected into the oxygen stream and passes through the flame, coming into intimate contact with the metal being scarfed.

Heliwelding is a descriptive term originated by Air Reduction to cover its activities in the increasingly important field of inert-gas-shielded arc welding. Although the idea of shielding a welding arc with an inert gas is old, it attained commercial importance during the war years in meeting the urgent need for a better method of welding magnesium, aluminum and stainless steel. Further research on the heliwelding process has demonstrated its remarkable versatility for fabricating most of the ferrous and non-ferrous metals and alloys which hitherto have been considered difficult to weld. This has led to the development of an improved water-cooled heavy-duty manual holder and the recently introduced heavy-duty machine holder and fully automatic.

ALLEGHENY-LUDLUM ORDERS 40 IN. SLABBING MILL

▲ Allegheny Ludlum Steel Corporation has placed an order for a 40 in. electrically powered slabbing-blooming mill. The new mill, ordered for late 1948 delivery from Morgan Engineering Company will replace the blooming mill at the company's

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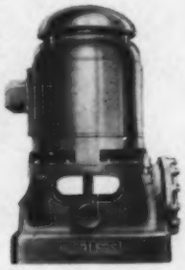

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Brackenridge, Pennsylvania, plant. The mill, with a 60-ton heavy duty crane, feeder and approach tables and electrical equipment will cost about $3,500,000, it was said.

One of the outstanding features of the mill will be its twin-motor drive. Instead of having a single electric motor with pinion gear reduction drive, separate motors will power the upper and lower rolls independently.

The new equipment will be installed without interfering with production at the Brackenridge plant. The new mill is being designed expressly for working stainless and other high alloy steel ingots.

GARY WORKS TO HAVE 77 NEW COKE OVENS

▲ Carnegie-Illinois Steel Corporation announced awarding of a contract for a new and 16th coke oven battery at Gary steel works. The new coke oven battery will be built by the Wilputte Coke Oven Corporation and construction will be undertaken at once.

The battery will include 77 ovens with a daily coke production capacity of 1096 tons. This battery will increase the Gary works coking installation to 1132 coke ovens. The Gary coke plant ranks second only to the Carnegie-Illinois coking facilities at Clairton, Pennsylvania.

ROTATING REGULATOR DEVELOPMENTS

By E. E. Vonada

Reliance Electric and Engineering Company

▲ For years engineers of the Reliance Electric and Engineering Company have been actively identified with the development and application of regulators to a-c and d-c run-out table motors, to tension reels, to wire blocks and to other steel processing equipment drives where tension, speed, or voltage need to be controlled.

One of the earliest of these developments, the Miller regulator, designed and built by Reliance in 1930, used conventional motor and generator parts in its construction, thereby assuring dependability.

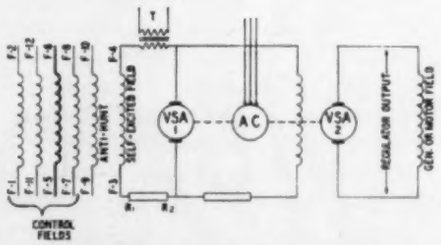
Since the advent of the Miller regulator, the electrical industry has developed other regulators, each striving to achieve improvements in one or more important respects, such as accuracy, speed of response, versatility, amplification, dependability, or combinations of these features.

With the reconversion of plants to production of peacetime products, there has developed a steadily increasing demand for automatic regulators. As a consequence, in addition to using regulators built by other manufacturers, Reliance found it advisable to set its own engineers to work to produce a regulator for its own applications which would incorporate all of the latest improvements known to the art.

Numerous design, manufacture, and test cycles were required before the device introduced as the VSA regulator met the stipulated conditions.

In its final form, this new regulator consists essentially of two standard exciters driven by a small a-c motor. With this arrangement, the simplicity

Figure 1 — Schematic diagram of VSA regulator.



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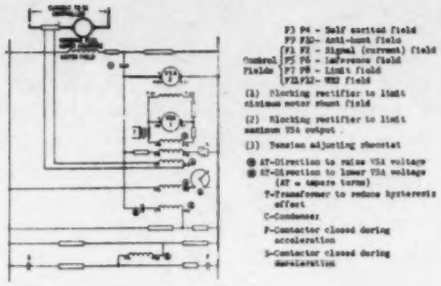
F1 F4 - Self excited field
F2 F10- Anti-hunt field
F3 F7 - Signal (current) field
Control F5 F6 - Reference field
Fields F7 F8 - Limit field
F11F12- VHZ field
(1) Blocking rectifier to limit minimum motor shunt field
(2) Blocking rectifier to limit maximum VSA output .
(3) Tension adjusting rheostat
AT-Direction to raise VSA voltage
AT-Direction to lower VSA voltage
(AT = ampere turns)
T-Transformer to reduce hysteresis effect
C-Condenser
P-Contactor closed during acceleration
D-Contactor closed during deceleration

Figure 2 — Connection for winding reel application.

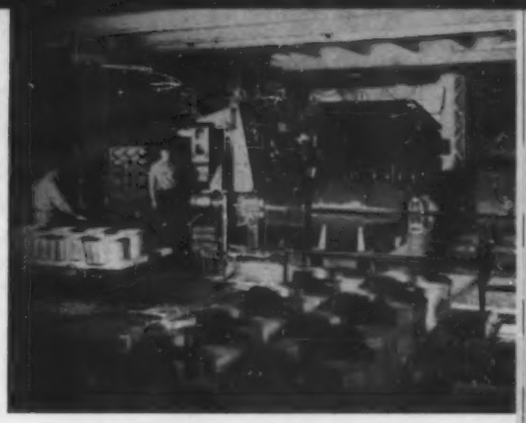

Figure 3 — Typical installation of a VSA regulator.

and dependability of standard rotating equipment parts has been retained. What is equally important, the regulator is easy for the plant electrician to understand and requires little adjustment.

The ability to increase the kilowatt rating of the output exciter greatly enhances the flexibility of the new regulator since it can be built to handle any motor or generator field directly without the necessity of using a separate counter emf motor-generator set to handle the field power requirements of larger motors and generators. For current limit acceleration and deceleration applications, a low voltage generator is added to the regulator set, thereby eliminating the necessity for mounting and wiring a separate set.

The new regulator is shown schematically in Figure 1. The first or control exciter, designated as VSA-1, has four control fields, an anti-hunt field and a self-excited field, all acting on common poles. To reduce residual and hysteresis in this unit, the frame and pole pieces are built from laminated special steel sheets, and the end rings and pole mounting bars are of special steel. Additional residual control is provided by introducing an alternating current into this self-excited field. With these measures it is possible to maintain a plus or minus one per cent regulating accuracy. Greater accuracy can easily be obtained by signal amplification.

This first exciter (VSA-1) furnishes practically all the excitation required to support its own voltage. With the self-excited field properly adjusted to provide for its self excitation, a maximum differential of four ampere turns in any of the other control fields will cause the regulator to cover its complete voltage range at the rate of 1000 volts per second unless restrained by the anti-hunting circuit. Since the control fields are normally designed to operate at a maximum of 200 ampere turns per coil, it can readily be seen that the required ampere turns for control are but a very small percentage of the total ampere turns available and amply provide, therefore, for field forcing when required.

As indicated in Figure 1, the output of the first unit supplies excitation to the field of a second, or VSA-2, standard exciter, thereby providing desired amplification. With this ar-

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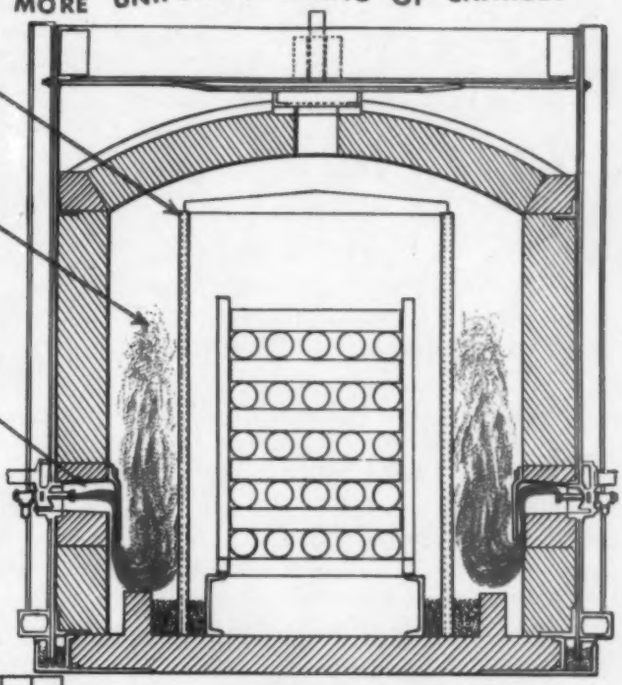

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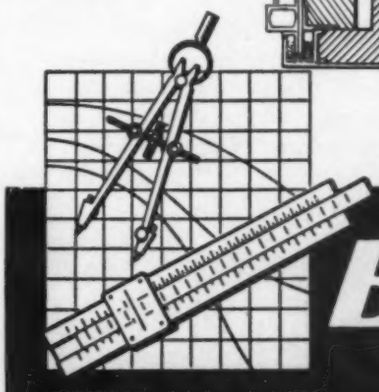

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rangement a 0.003 watt signal change in the first unit will produce full wattage of the second unit.

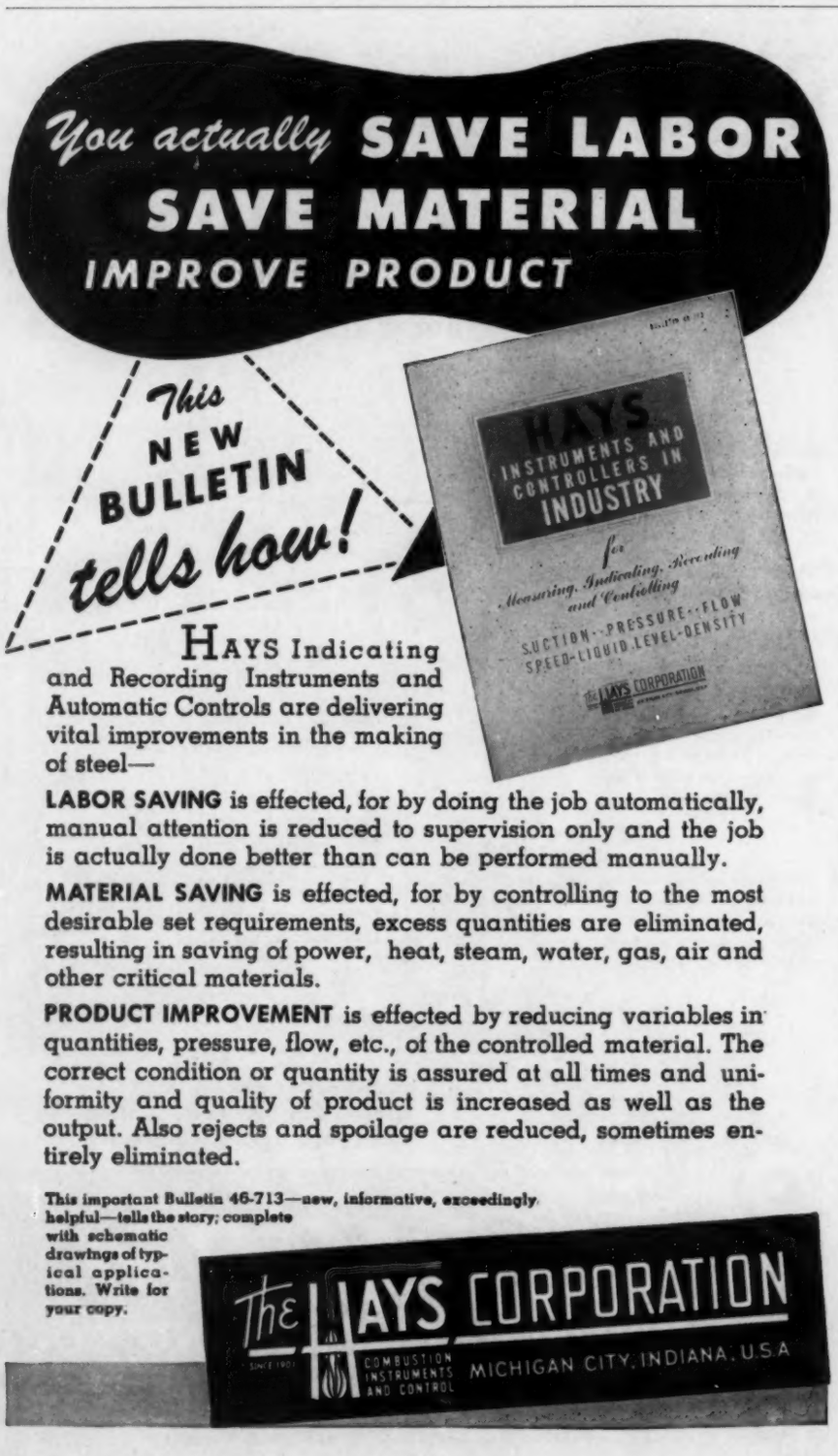
The amplification and speed of response provided in the new regulator greatly exceeds the time constant of the field normally used in conjunction with the regulators and requires a damping or slowing-down action to prevent extreme hunting or oscillation. A field is provided in the VSA-1 unit for this specific purpose. The desired anti-hunting is obtained by using a combination condenser-resistance arrangement in the anti-hunt field circuit. The anti-hunting is based upon the output voltage of the VSA-2 unit rather than upon the normally amplified VSA-1 unit to make this anti-hunting circuit more effective.

A control field is provided in the VSA-1 unit for providing WR^2 correction during acceleration and deceleration when the regulator is used on reeling applications. This separate field permits easy adjustment for WR^2 compensation and eliminates the necessity for providing for this compensation in one of the normal control fields. On voltage regulating applications where WR^2 compensation is not required, this field is normally connected across a load resistor to provide an automatic IR drop compensation.

The remaining three control fields are available for inclusion in control circuits to provide regulating and auxiliary control functions.

Figure 2, shows a typical regulator connection for a winding reel application when regulating for constant current. By replacing field F1-F2 the regulator is adaptable to speed and voltage regulating problems. On current limit spill-over applications, normally encountered when rapid reversing of the motor is required, the three main control fields are replaced by fields having different current and resistance values.

This necessity for substituting fields makes it important that adequate information is available regarding the expected applications of the regulator, so that the necessary field characteristics can be supplied. A regulator built for tension regulation can, with proper field resistance adjustments, be moved from one tension application job to the next so long as the kilowatt rating of the output unit is not exceeded. This same flexibility is applicable for regulators that have been designed for speed or voltage applications.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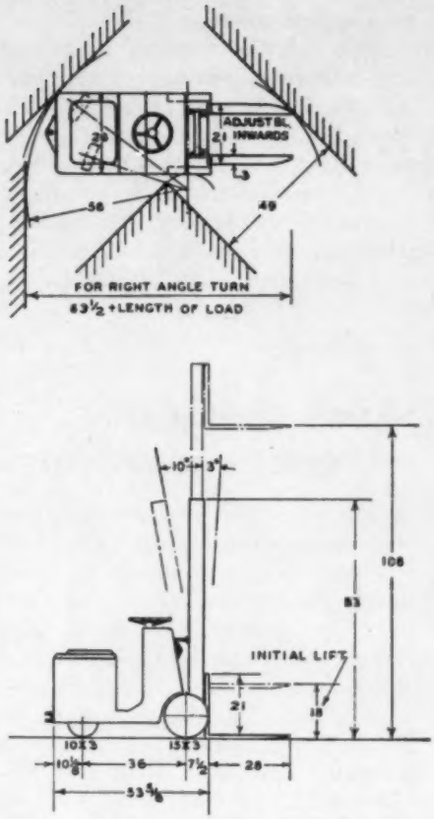
▲ The Baker Industrial Truck division of the Baker-Raulang Company announces the Type FQH-10 center-control fork truck which is designed to meet the need for a small, lightweight and low-priced fork truck of 1000 lb capacity. Developed about four years ago, an initial model was built and this truck since has been in continuous use. After the first truck had undergone a thorough test other experimental models were built embodying certain improvements and other desirable changes and were subjected to exhaustive proving first in the Baker plant and afterwards in other plants under actual service conditions. A pilot truck of the production model has been built and



A right angle turn can be made with this truck in 97½ in.

tested and quantity production has been started for delivery in March 1948.

This truck has a 36-in. wheelbase and an overall length, exclusive of forks, of 53⅝ in. To make a right angle turn the truck requires only 67½ in. plus the length of the load, and since the truck is designed for a 1000-lb load 30 in. long, a right angle turn can be made in 97½ in. The truck is only 28 in. wide. This compact construction permits operation under the conditions described above. Thus, the advantages of power fork truck operation are made available to a large class of users that has been prevented in the past from using the larger type of power industrial truck equipment.

Its light weight — only 3800 lbs with load — permits its use on floors having limited capacity, on low capacity elevators and in highway truck loading. The danger of breaking through truck floors, which is present when higher capacity industrial trucks are used, is eliminated. This truck provides the advantage of faster loading of material by shipping departments, saving waiting time of the

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highway trucks and congestion in the shipping department.

Although the truck is both short and narrow, it is one of the most stable fork trucks on the market. The dimension from the center of the drive wheels to the heel of the forks is only 7½ inches, which contributes materially to fore-and-aft stability, which means protection to employees and prevents damage to material.

METALS COMPARATOR CHECKS COMPOSITION

▲ An electronic instrument called the metals comparator has been introduced by the special products division of the General Electric Company for providing a quick, nondestructive comparison of either magnetic or nonmagnetic metal parts with a standard. Parts appearing alike but differing in composition can be separated quickly with the new instrument. It has been used to differentiate between annealed and unannealed steel bars, and also to sort finished metal parts with different compositions or heat treatments.

The metals comparator employs a network and indicating instrument mounted in a steel cabinet to which is connected an external test coil. In operation, a reference specimen for the group of specimens being compared is first placed in the test coil and adjustment made to secure the initial balance. This is indicated by a zero

The comparator is mounted in a steel cabinet weighing less than 60 lb.

reading on the indicating instrument. After the reference specimen has been removed, the parts to be tested are inserted briefly in the coil one by one. When tolerances have been established, specimens can be accepted or rejected on the basis of the dial reading. As many as 1500 small parts can be tested in an hour.

The metals comparator is mounted in a steel cabinet about 11 × 17 × 22 in. and weighs a little less than 60 lb. Test coils of different sizes are available, ranging from ½ in. to 3 in. inside diameter. Leads are of convenient length so specimens can be tested in any position adjacent to the instrument.

The equipment is designed for operation from 60-cycle commercial power supply at 115 volts. Because of the small size of the apparatus and the low power requirements, the instrument can be used in almost any location.

BENDING PRESS FOR HEAVY METAL SHEETS

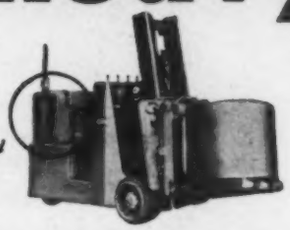
▲ A new 500 ton press with unusually long bed has been added to the "Steelweld" bending press line manufactured by Cleveland Crane and Engineering Company to satisfy an increased demand for machines that will handle larger and heavier sheets of metal.

This press, known as Model Mo6-14, has a 20 ft bed and ram which permits bending steel plate up to 20 ft × ⅜ in. or 14 ft × ½ in. Twenty-one-inch bed extensions on both ends make possible horning operations. To minimize deflection and assure accuracy, the bed extends 42 in. below the floor.

This is a two-speed machine which can be operated at either 7 or 20 strokes per minute. It is equipped with tonnage indicators on both ends that show the loading to which the machine is subjected. A clutch knock-out mechanism disengages the clutch when the press is overloaded. The back gauge being motor-driven, is quickly and easily adjusted to proper position.

The machine shown is operated by a mechanical foot treadle, but when desirable, air-electric control can be provided enabling the use of an electric foot switch which may be slid around the floor in front of the

heavy loads need READY-POWER



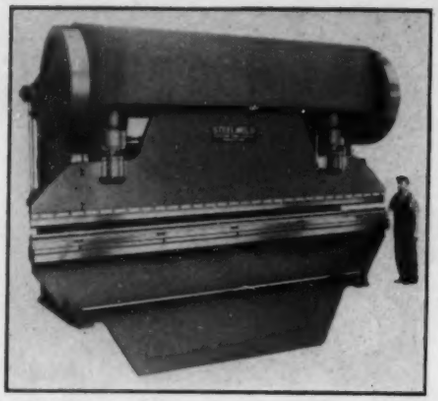
Ready-Power-equipped Baker truck

There's plenty of power to handle heavy loads all day when trucks are equipped with Ready-Power gas-electric Units. Dependable electric power, generated right on the truck chassis, assures smooth, positive handling. Models are available to meet practically all requirements. Convert any make truck to Ready-Power; specify Ready-Power Units on new truck purchases.

THE READY-POWER CO.

3836 Grand River Ave., Detroit 8, Michigan

See Ready-Power Units on display at the Second National Material Handling Show — Booth 401



This press has a 20 ft bed and ram. Bed extensions of 21 in. on each side make possible horning operations.

machine to any position most convenient for the press operator. This type control is especially recommended for fast production.

These presses are available for bending, forming, blanking, drawing, rubber-forming and multiple-punching. Extra wide bed and ram may be had to accommodate large dies and other features may be incorporated to suit special conditions.

U. S. STEEL PLANTS ESTABLISH NEW RECORDS

▲ In October Pittsburgh district plants of two United States Steel subsidiary companies established eight all-time records. Topping the list are a new world's record of 166,338 tons of strip steel and almost a million tons of steel ingots from Pittsburgh district open hearths of Carnegie-Illinois Steel Corporation, the largest tonnage ever achieved with existing facilities.

The strip steel record was made at Irvin works of Carnegie-Illinois, where the 80-in. continuous strip mill exceeded its previous high of 153,784 tons produced in January 1947.

The new Pittsburgh district open hearth ingot tonnage mark of this subsidiary is 972,697 tons. The old record was 963,588 tons, also made in January 1947.

The other records are:

National works, National Tube Company — 104,975 tons of steel ingots; old record, 104,246 tons in October 1946. Also a pipe record of 25,690 tons on this plant's No. 1 seamless mill; old record, 25,274 tons in April 1946.

Homestead steel works, Carnegie-Illinois — 370,369 tons of steel ingots; old record, 366,882 tons in May 1947. In addition, Homestead's 45-in. slab mill recorded 168,481 tons of slabs; old record, 159,792 tons in May 1947.

Edgar Thomson works, Carnegie-Illinois — 155,769 tons of steel ingots; old record, 151,534 tons in March 1944.

Duquesne works, Carnegie-Illinois — 12,560 tons of electric furnace high grade alloy and stainless steel ingots; old record, 11,558 tons in January 1944.

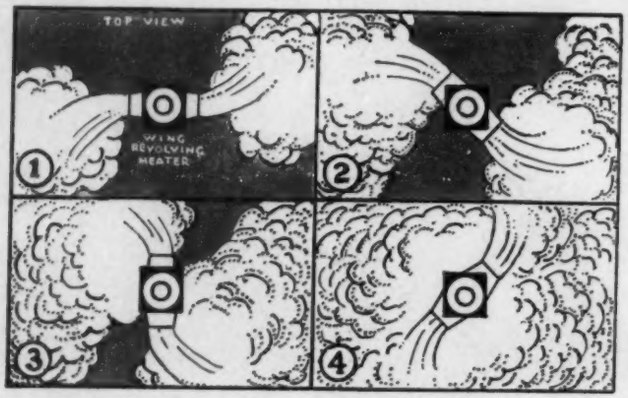
SHEET AND TUBE TO EXPAND CAPACITY

▲ Youngstown Sheet and Tube Company plans to boost coke and iron production at its Indiana Harbor plant in East Chicago, Indiana, next summer. Seventy-five new coke ovens are to be built and the No. 1 blast furnace is to be rebuilt and enlarged from 800 to 1400 tons per day. Work is to begin as early next spring as weather and materials will permit.

Methods used in rebuilding a blast furnace in the Youngstown district during the war will be followed at Indiana Harbor to reduce iron loss as much as possible. The new furnace will be built on a temporary structure about 120 ft from the present furnace while the present furnace is being dismantled. The new stack will later be moved onto the foundation pad of the present furnace. During World War II this method was used at the Campbell, Ohio, plant and reduced the rebuilding time 67 days.

The 75 new ovens will boost coke production about 35,000 tons a month and will balance coke supplies with increased iron production.

Two projects are under way at the Indiana Harbor plant at present. A new overhead gas line, five feet in diameter, is being constructed between the blast furnaces and the soaking pits to provide blast furnace gas for the soaking pits. The other project is replacing three old boilers with a new steam generator capable of producing 175,000 lb of steam per hour with a working pressure of 800 psi.



Revolving Discharge Outlets for Thorough Heat Coverage

Wing Revolving Unit Heaters keep the heated air moving, circulating around obstacles, seeking out far corners, spreading an even, uniform, healthfully invigorating blanket of warm air over the entire working area. Wing Revolving Unit Heaters do what *no other form of plant heating* can do. They circulate the warm air completely and thoroughly over the entire working area, regardless of obstructions. They eliminate unhealthful hot and cold spots, chill corners or sickening, concentrated blasts of hot air.

Write for Bulletin HR-5

L. J. Wing Mfg. Co.

142 W. 14th Street
New York 11
Factories:
Newark, N. J. and
Montreal, Can.

Wing REVOLVING UNIT HEATERS

LORAIN ORE DOCKS COMPLETELY RENOVATED

Complete renovation of this dock on the Black River at Lorain, Ohio, where iron ore arrives from Minnesota, is one of the first-to-be finished improvements in a $100 million modernization and expansion program at U. S. Steel's National Tube Company plant there. The Lorain program includes a new coke plant, the first continuous seamless pipe mill ever built, modern blooming, bar and billet mills, and entirely new bessemer steel plant, and a three-acre warehouse to facilitate pipe shipments. It is one of the biggest postwar steel plant construction projects in the country and is part of the $500 million expansion that U. S. Steel has well underway. The dock improvement insures efficient handling of heavy ore shipments required to feed the plant's busy blast furnaces.

H. K. PORTER DEVELOPS LUBRICATED PLUG VALUE

▲ H. K. Porter Company, Inc., has announced the development and production of an advanced design of lubricated plug valves. These valves assure complete and leak-proof shut-off, elimination of leaks through the stuffing box, ease of operation, and trouble free service. The valve is available in semi-steel, carbon steel, alloy and stainless steels.

I-T-E ACQUIRES RAILWAY INDUSTRIAL

▲ I-T-E Circuit Breaker Company has announced the acquisition of the Railway and Industrial Engineering Company effective November 1, 1947.

This merger is significant to the electrical industry because it unites two prominent manufacturers of electrical switchgear equipment. I-T-E has been a pioneer in the field of air circuit breakers and assembled switchgear utilizing air circuit breakers. Railway and Industrial Engineering Company is primarily a manufacturer of high voltage disconnect switches and outdoor unit substations. Both companies have been active in the development and sale of high voltage isolated phase bus.

Operation of both companies will continue as formerly. Gross annual volume of business for the combined companies is estimated to be in excess of 20 million dollars.

ROLLING MILL FOR ROLLING CLADMETALS

▲ The fast growing cladmetals industry should soon see in operation the first rolling mill plant which has been designed especially to make only cladmetals. The substantial investment to be represented by the mill, which is being readied for American Cladmetals Company at Carnegie, Pennsylvania in a plant 800 ft long × 125 ft wide, emphasizes the importance of the comparatively new cladmetal industry.

The mill will be streamlined for simplified economical production of its highly specialized product, a new-

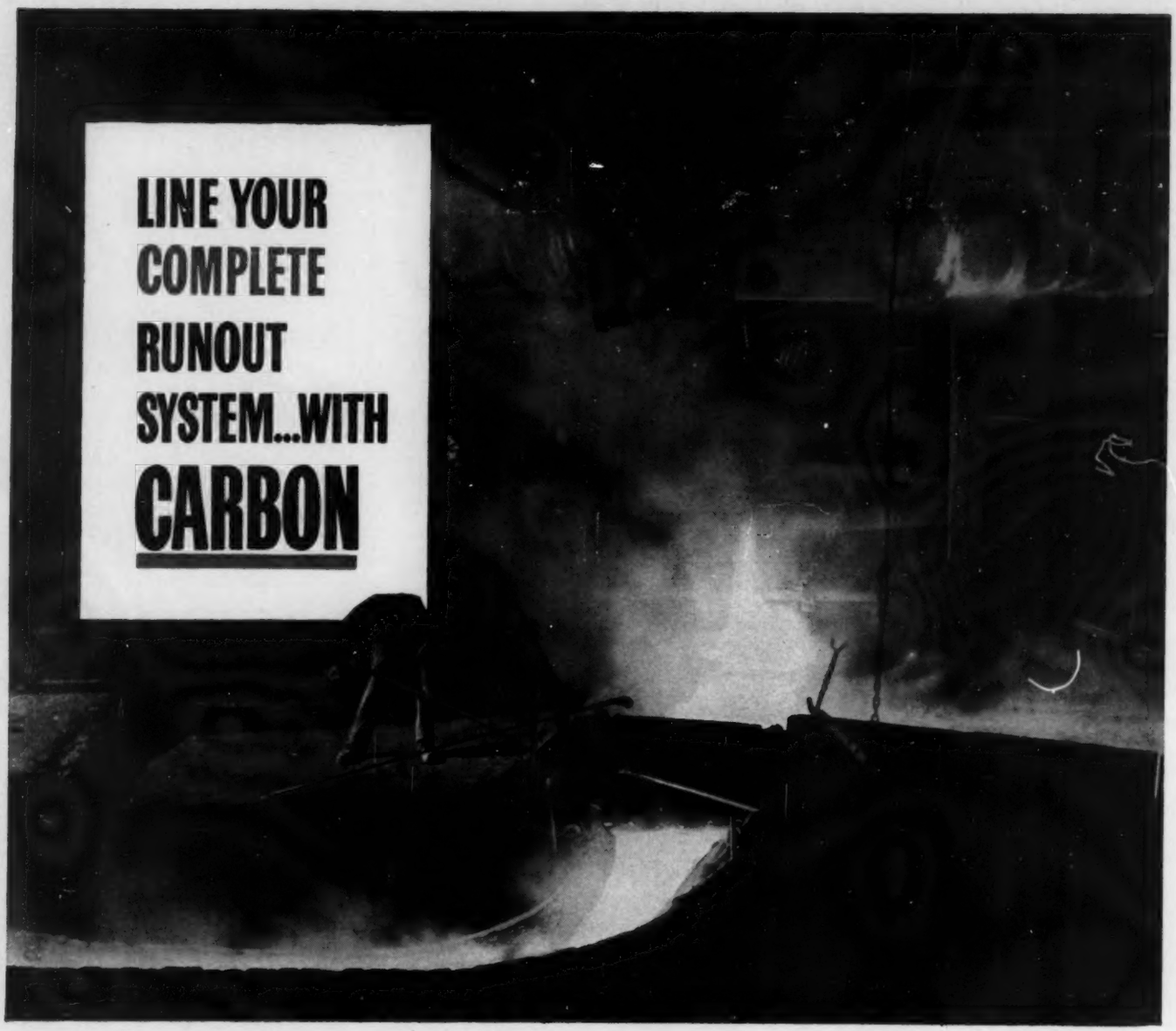
(*Please turn to page 151*)

With the New
URQUHART COMBUSTION PROCESS
"just a twist of the wrist"...

Converts from Oil to Gas or Gas to Oil

Write for Installation Data on Industrial Applications from Soaking Pits to Forge Furnaces

SPC
Steel Processing Co.
Subsidiary of FORT PITT BRIDGE WORKS
KEYSTONE HOTEL BLDG., PGH., PA.



● "National" carbon-block linings have for years been doing a fine job in blast furnace runout troughs —between taphole and skimmer plate.

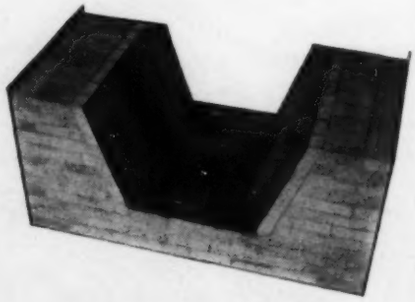
Why stop there?

Why not use carbon linings for the entire system, from furnace to ladle, and in the lead-in spouts of the pig machine as well? Carbon-block construction, shown at right, is recommended to the skimmer plate. Carbon bricks are most practical for the rest of the troughs.

Why use carbon?

Carbon outlasts other trough linings by months, even years. It is unaffected by thermal shock. Hot metal will not stick to carbon; so, if any skull is formed in the trough, it is readily removed. Furthermore, if you desulphurize in the trough, you'll find that carbon is highly resistant to desulphurizing agents.

Here is the recommended construction for a carbon-block trough between taphole and skimmer plate. Dark section is carbon. Light section is firebrick.



NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation
The term "National" is a registered trade-mark of National Carbon Company, Inc.

UCC

30 East 42nd Street, New York 17, N. Y.
Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

Personnel News . . . .

S. C. Read was appointed manager of maintenance for Jones and Laughlin Steel Corporation. This newly created position, under the vice president-operations, is for the purpose of supervising and co-ordinating maintenance work throughout the corporation and its subsidiaries (with the exception of the railroads). Mr. Read started to work for the corporation in 1924 as assistant superintendent, power department, south side works. In 1938 he was made master mechanic of rolling mills, Pittsburgh works. In March 1946, he was appointed superintendent of blooming department and rolling mills, Pittsburgh works, in which position he served until his current promotion. Mr. Read attended Purdue University and the University of Michigan, graduating from the latter with a degree in mechanical engineering. He later received a master's degree in metallurgical engineering at Carnegie Institute of Technology.

Forest J. Smith was promoted to the position of supervisor of labor relations for Carnegie-Illinois Steel Corporation with headquarters in Pittsburgh. Mr. Smith will succeed A. H. Wardwell who will leave Carnegie-Illinois to become director of raw materials of the American Steel and Wire Company, also a U. S. Steel subsidiary. Mr. Smith, who began his association with Carnegie-Illinois as a recorder in the plant 32 years ago, was superintendent of industrial relations at Gary steel works. Mr. Smith held various plant positions in the chemical laboratory organization before becoming assistant superintendent of industrial relations 11 years ago. On March 16, 1939, he became industrial relations superintendent and continued in this position until his current promotion.

Earl H. Fyler was made superintendent of industrial relations at Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Fyler joined Carnegie-Illinois in 1930 as a sales student. He held various industrial relations positions in Chicago, at South Chicago and at Gary works before becoming industrial relations superintendent at South Chicago works two years ago.

Herman A. Enemark was appointed superintendent of industrial relations at Carnegie-Illinois Steel Corporation, South Chicago, Illinois. Mr. Enemark started as a Carnegie-Illinois stenographer 12 years ago. He later became a sales student and then transferred to industrial relations work. He has been at South works for the last two years, holding the position of assistant superintendent of industrial relations.

Riley R. Clark, senior rate engineer of the company in Pittsburgh, has been appointed Herman A. Enemark's successor as assistant superintendent of industrial relations at South works of Carnegie-Illinois Steel Corporation.

E. L. "Buck" Ramsey, who retired recently as superintendent of steel production, Wisconsin Steel division of International Harvester Company, has resumed active work in the steel industry as a technical consultant with Miller and Company. For more than 40 years, Mr. Ramsey has been a leader in the development of steel processes in open hearth methods. His retirement in May as superintendent of steel production for Wisconsin Steel ended a 25 year tenure with this company, during which time he was instrumental in the development of Wisconsin's open hearth plant. Mr. Ramsey has been a steel man since his first job with Carnegie Steel Company at Farrell, Pennsylvania plant in 1901. Following this his service in the industry chronologically was: U. S. Steel Corporation, 1902; Republic Steel Corporation, 1912; Mesta Machine Company, 1917; then Wisconsin Steel.

John Donnelly, electrical superintendent of Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ontario, Canada, retired November 30 after 37 years of service.

Joshua L. Miner, retired recently as vice-president, Lumnite division, Universal Atlas Cement Company, a United States Steel Corporation subsidiary. Mr. Miner joined Universal Atlas in 1922 and in 1924 became identified with the subsidiary company which was formed to produce Atlas Lumnite cement. In 1937 he was elected director and vice-president of that company. After graduating from Lafayette College in 1903, Mr. Miner began work as chemist for another cement company, spent ten years prior to 1922 as manager for the Pittsburgh Testing Laboratory in Dallas and New York.

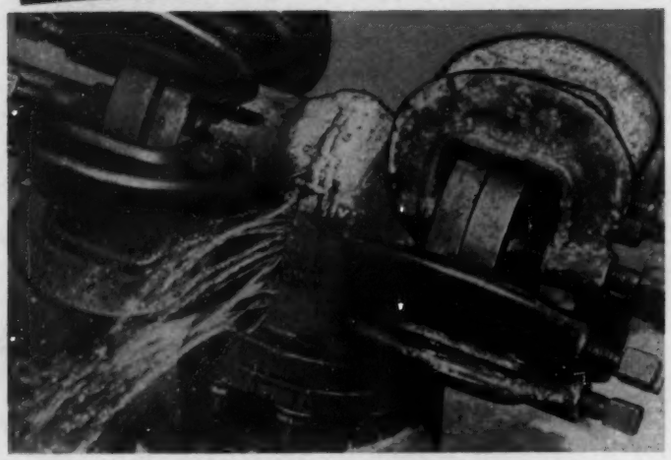
S. C. READ

FOREST J. SMITH

EARL H. FYLER

E. L. RAMSEY

METALOCK
Registered Trademark
A MECHANICAL REPAIR FOR WRECKED MACHINERY
THOUSANDS SAVED BY *On location* REPAIRS WITH METALOCK



2200 psi held by METALOCK Repair.

In official Navy test a 3 in. valve, tested to destruction, ruptured outside the repaired area leaving repair intact.

METALOCK REPAIR SERVICE
General Office: Pennsylvania Division, 530 WILLIAM PENN PLACE
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HOME OFFICE: LONG ISLAND CITY 4, NEW YORK

Here's What Happens to Your
NON-FERROUS CASTING ORDER AT FALCON

Falcon Bronze is a company owned by the casting specialists who work there. When your non-ferrous casting order arrives — by phone, wire or mail — it comes to the immediate attention of these working-owners. Without departmental routine or other impersonal delay, patterns are promptly readied and production started. Close, expert supervision through each step of production eliminates possibility of your order becoming side-tracked, assures highest quality standards of casting. A final, close check to make sure that every requirement has been met, that flawless casting has been accomplished — and another fast, satisfactory delivery is on its way.

When you need quality castings in a hurry, try the personal attention of Falcon specialists.

TELEPHONE COLLECT - 3-4355
FALCON BRONZE CO.
YOUNGSTOWN 3, OHIO
Established 1890 • Incorporated 1895

Illustrated is an installation of Falcon-produced Kinney Refractory-Lined Tuyere Cooler, U. S. Pat. App. Serial 530153, and Holsworth "Split Nose" Tuyere, U. S. Pat. 1,789,870.

Robert J. Peck was made district manager of the Electric Products Company's New York office. Mr. Peck will handle all sales and service negotiations in the territory which consists of the New England states, Eastern New York and Pennsylvania, New Jersey, Delaware, Maryland and Virginia. A graduate of New York University in 1930, Mr. Peck has since then been

ROBERT J. PECK

actively engaged in the selling, engineering and servicing of electrical products. He joined the Electric Products Company in May 1947.

Frank Lobaugh was made manager of the Lumnite division of Universal Atlas Cement Company. Mr. Lobaugh attended the University of Pittsburgh and Alfred University, Alfred, New Jersey, where he specialized in ceramic engineering and where he subsequently received his degree of ceramic engineer. From 1930 to 1940, he was assistant professor in ceramic engineering at Alfred University.

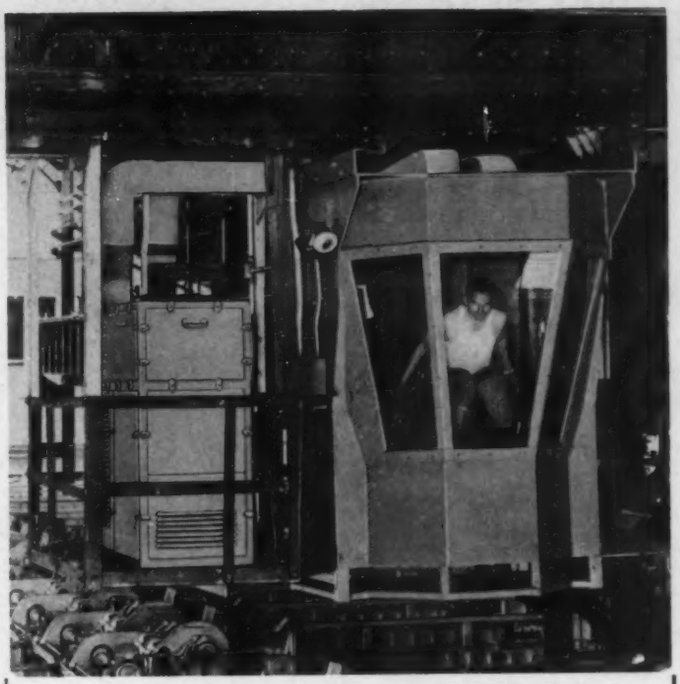
In 1941, Mr. Lobaugh joined the Lumnite division of Universal Atlas in the technical division and sales department. He was appointed technical service director in 1944.

R. F. Holtz was appointed assistant to the general traffic manager of U. S. Steel's American Bridge Company, Carnegie-Illinois Steel Corporation, H. C. Frick Coke Company, National Tube Company and United States Coal and Coke Company. Mr. Holtz, who formerly held the position of assistant to the traffic manager, Pittsburgh district, has been affiliated with subsidiaries of U. S. Steel Corporation for 41 years in traffic and transportation work.

Paul S. Park has been named manager of the engineering service department of A. M. Byers Company, Pittsburgh, Pennsylvania. A graduate of the University of Pittsburgh in mechanical engineering, Mr. Park served as an officer in the Army Air Forces during World War II. He has been with A. M. Byers Company nearly four years.

William T. Strickland has been made a sales engineer for Timken Roller Bearing Company at Chicago, Illinois. Mr. Strickland also received a bachelor of science degree in metallurgical engineering from Case Institute of Technology. After graduation he

(*Please turn to page 137*)



Soaking Pit Crane in plant of a prominent steel company, equipped with Lintern Aire-Rectifier 145 AC-24.

The Only Crane Cab Conditioner Thoroughly Tested on Soaking Pit Applications

The Lintern Aire-Rectifier, shown in the above illustration, is one of several in a large eastern steel plant.

After thoroughly testing the Aire-Rectifier on their soaking pit cranes, the company chose this unit for several other applications in the steel mill.

Lintern *balanced refrigeration* design prevents overloads in temperatures as high as 170 F. This is the only crane cab conditioner which has had thorough testing on soaking pit applications. It has been tried and has proven itself. Only periodic inspection is required. Over the years it has demonstrated its *low* maintenance.

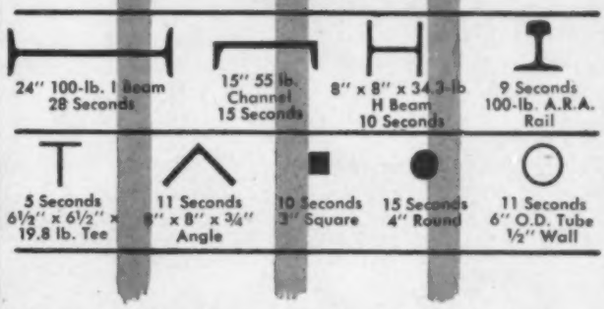
Ask for Bulletin AC 82147.

THE LINTERN CORPORATION
54 LINCOLN AVENUE - - BEREA, OHIO

Glowlite Signals, Lanterns, Sanders, Shock Absorbers for Lamps, Ventilating Heaters, Aire-Rectifiers Overhead Cranes

Modern Sawing

with KLING HIGH SPEED FRICTION SAWS


24" 100-lb. I Beam 28 Seconds
15" 55 lb. Channel 15 Seconds
8" x 8" x 34.3-lb H Beam 10 Seconds
9 Seconds 100-lb. A.R.A. Rail
5 Seconds 6½" x 6½" x 19.8 lb. Tee
11 Seconds 8" x 8" x ¾" Angle
10 Seconds 3" Square
15 Seconds 4" Round
11 Seconds 6" O.D. Tube ½" Wall

Friction sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or set-up, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

Consult Kling engineers regarding your metal cutting problems. State size of material to be cut. Bulletin No. 9200 giving full particulars and suggestions as to the type and size of saw will be mailed promptly. No obligation.

KLING BROS. *Engineering Works*

Punches; Bar, Angle and Rotary Shears; Combination Shear, Punch and Copers; Plate and Angle Bending Rolls; Heavy Duty Grinders

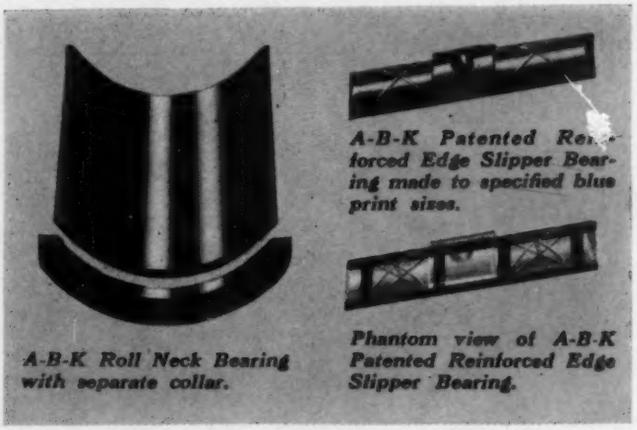
1324 N. KOSTNER AVENUE, CHICAGO 51, ILLINOIS, U. S. A.

Why are steel mills switching to LAMINATED PLASTIC BEARINGS?*

1. Here's why steel mills are switching to Laminated Plastic Bearings. Records kept by many mills show laminated plastic bearings impressively superior to metal bearings. Investigate these important reasons that stand behind the trend to laminated plastic bearings. One prime consideration is that . . .

2. Laminated Plastic Bearings outwear metal bearings. These bearings customarily have a trouble-free life many times longer than metal bearings. This means fewer shutdowns for bearing replacements. Close tolerances are held with a minimum of roll adjustments. Lost production hours are substantially reduced. Then, too, . . .

3. Lubrication costs are practically eliminated. Water is used to lubricate and cool laminated plastic bearings—no oil or grease. The hard, smooth surface of these bearings, when water lubricated, has an exceptionally low coefficient of friction which results in remarkable power savings. To be sure of these advantages, . . .



A-B-K Roll Neck Bearing with separate collar.

A-B-K Patented Reinforced Edge Slipper Bearing made to specified blue print sizes.

Phantom view of A-B-K Patented Reinforced Edge Slipper Bearing.

4. It is important to specify A-B-K Laminated Plastic Bearings. American Brakeblok Division, American Brake Shoe Company, has designed and engineered A-B-K Laminated Plastic Bearings to take the severest demands of peak production. In service they have proved their ability to make surprising cuts in operating costs.

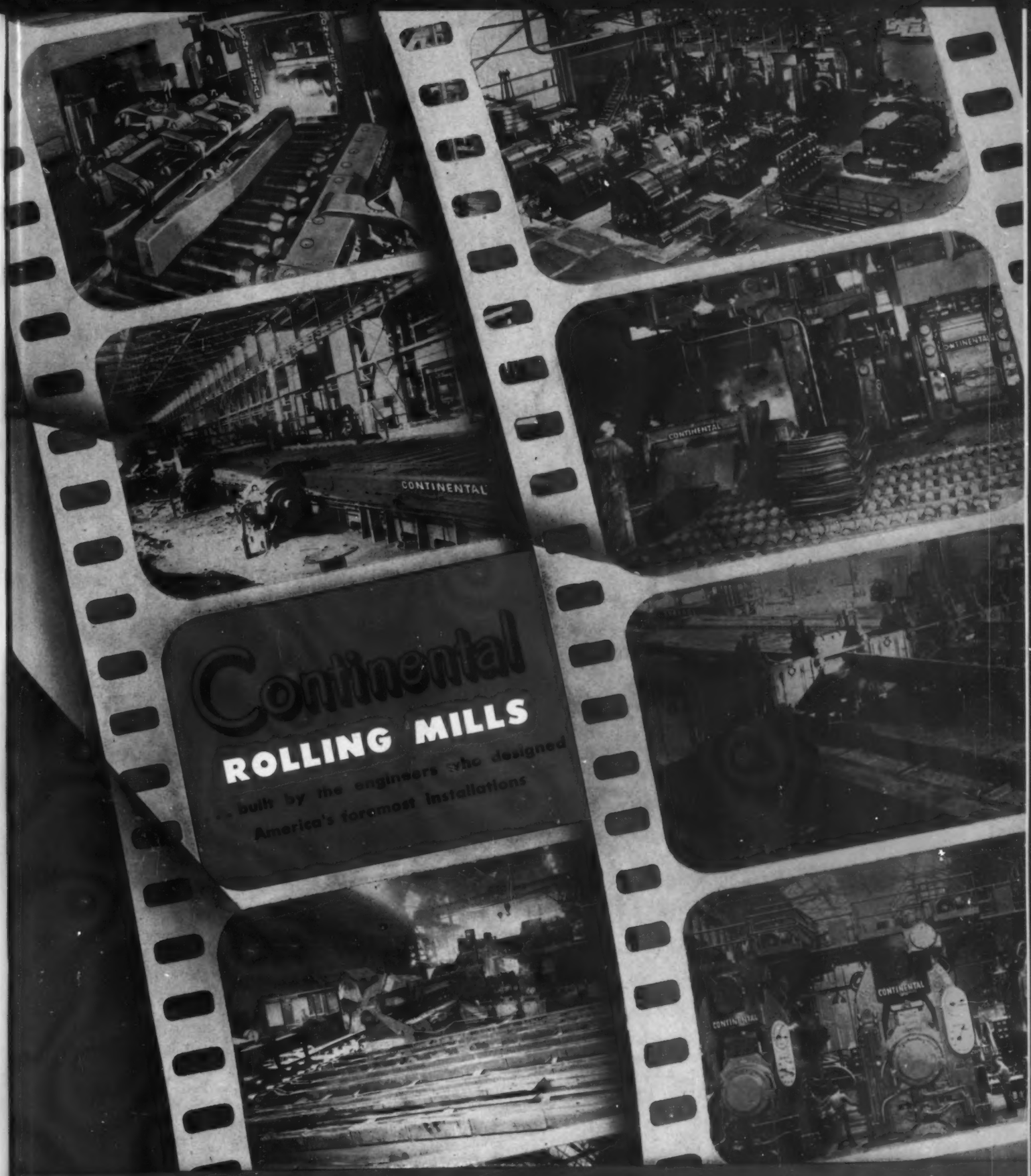
5. For full information on A-B-K Laminated Plastic Bearings and their applications to your steel mill bearing problems, communicate with American Brakeblok Division, 4600 Merritt Avenue, Detroit 9, Michigan.

American Brakeblok

*A·B·K Laminated Plastic Bearings

Brake Shoe

AMERICAN BRAKEBLOK DIVISION • DETROIT 9, MICHIGAN



Continental

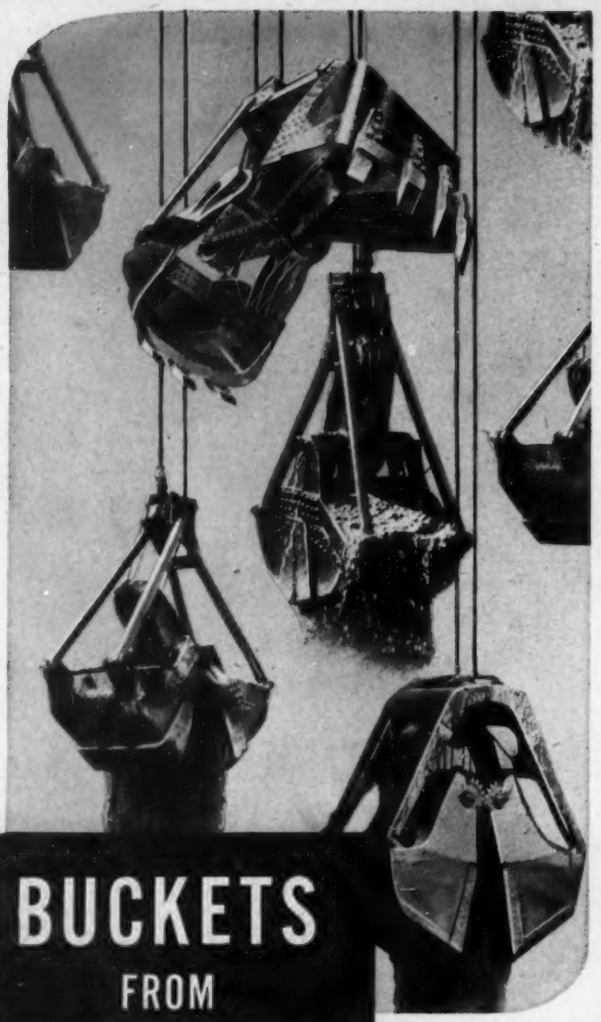
Continental

FOUNDRY & MACHINE CO.

CHICAGO · PITTSBURGH

Plants at East Chicago, Ind., Wheeling, W. Va., Pittsburgh, Pa.

Factory Headquarters for Carbon and Alloy Steel Castings, Rolling Mills and Equipment, Iron and Steel Rolls



BUCKETS FROM HEADQUARTERS

To give you the utmost in efficient performance, Blaw-Knox makes hundreds of different types and sizes—from a ½ cu. yd. trenching bucket to a 25 ton ore bucket, and everything in between. So name the material to be handled or dug, the hook or crane capacity, the clearance limits, and Blaw-Knox can supply you with a bucket that's exactly right for the job in question.

SEND FOR IT CATALOG #2076

BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2040 Farmers Bank Building
Pittsburgh 2, Pa.

You can select *exactly* the bucket you need from the informative data and illustrations in Blaw-Knox Bucket Catalogs. Ask for a catalog —indicating the *use* you have in mind.

BLAW-KNOX BUCKETS

WILLIAMS-HAGER
FLANGED SILENT CHECK VALVES
THE WILLIAMS GAUGE CO.
PENNSYLVANIA AVENUE
PITTSBURGH 12, PENNSYLVANIA
This VALVE
saves thousands of dollars by eliminating serious breakdowns in pumps and piping systems.

THE WILLIAMS-HAGER FLANGED SILENT CHECK VALVE

is positive insurance against costly "Water Hammer"—built of materials to meet the requirements of any service, and pressures up to 6000 pounds. Write for new descriptive Bulletin WH-50 today.

THE WILLIAMS *Gauge* COMPANY
3076 PENNSYLVANIA AVE.
PITTSBURGH 12, PA.

(*Continued from page 132*)

was employed by the Superior Steel Company in Louisville, Ohio, and the Republic Steel Company in Canton. He joined the Timken Company in 1946, after serving four years in the Navy, and completed a sales training course prior to his assignment to Chicago.

Harry A. Wright has been named engineer-in-charge of control sales of the control section of the Allis-Chalmers electrical department. Holder of an engineering degree from Carnegie Institute of Technology, Mr. Wright has been associated with Allis-Chalmers since 1937. Prior to assuming his present post, he was staff engineer of the company's control engineering section, and before that an engineer in the switchgear department.

W. G. Miller was appointed assistant to the works manager at the Westinghouse Electric Corporation's Buffalo, New York, plant. Mr. Miller, who has been manager of the headquarters manufacturing staff in Pittsburgh, Pennsylvania, since January 1946, will be responsible for the transfer of direct current and large alternating current motors from East Pittsburgh to Buffalo and for the operation of those manufacturing sections at the Buffalo plant. A native of Rockwell, North Carolina, Mr. Miller was graduated from the University of North Carolina with the degree of bachelor of science in electrical engineering in 1933. After graduation he joined Westinghouse as a member of the graduate student training course and later worked in the motor division. From 1941 to 1945 he was methods engineer and staff supervisor in the Canton, Ohio, ordnance plant. He was named manager of manufacturing at Canton in 1945 and served in that capacity until returning to headquarters in 1946.

R. D. Mossman was made manager of advertising of Jones and Laughlin Steel Corporation. A native of Pittsburgh, Mr. Mossman spent ten years in the advertising agency business in Philadelphia before joining the advertising department of Jones and Laughlin in July 1944.

R. D. MOSSMAN

Charles D'W. Gibson and **John A. Hill,** vice-presidents of Air Reduction Company, Inc., were elected directors of the company.

Mr. Gibson, vice-president in charge of sales, joined the company as a salesman in 1919. After successively managing the Richmond, Virginia, and Detroit, Michigan, sales districts, in 1926 he was appointed assistant vice-president and general sales manager. Since 1937 he has been vice-president in charge of sales.

Mr. Hill, formerly secretary of the Air Reduction Company, Inc., was made vice-president in 1945.

William E. Bryden, sales engineer for Timken Roller Bearing Company, was transferred from the Chicago office to the Cincinnati office of the Timken steel and tube division. Mr. Bryden received a bachelor of science degree in metallurgical engineering from Case Institute of Technology. He joined the Timken organization in 1937 as an assistant in the metallurgical department. In 1940 be became sales engineer for the New York district. Following the outbreak of war, he served a year as a member of the steel division of the War Production Board. He joined the Navy in 1942, and was discharged in March 1946, and was assigned to the Chicago office in May 1946.

Harry C. Ellison, works manager, has retired after 52 years with Republic Steel Corporation's bolt and nut division and its predecessor companies, Bourne-Fuller Co. and Upson Nut Co. Mr. Ellison, however,

Steudel
Blast Furnace
TUYERES
by SMEETH-HARWOOD
Shaped to eliminate cutting underside of the nose.
Made to Smeeth-Harwood standards using molding and melting techniques developed and perfected thru years of specialization.
Place your next order for Tuyeres with Smeeth-Harwood. The superior quality made possible by specialized experience and know how means longer, more dependable service at no extra cost.
SMEETH-HARWOOD COMPANY
2401-09 West Cermak Road, Chicago 8, Illinois
Superior Blast Furnace Copper Castings Exclusively.

will devote part of his time to Republic Steel as a consultant. Mr. Ellison's career in Cleveland manufacturing commenced more than half a century ago when as a Western Union telegraph messenger he frequently delivered telegrams to the bustling Cleveland concern, the Upson Nut Company. One of the officials of the company took a liking to the boy and persuaded him to take a job as an apprentice with the company. In the years that followed Mr. Ellison was transferred from one department to another until his knowledge of the entire workings of the bolt and nut manufacturing trade made him the logical candidate for manager of the plant. He became an employee of Republic Steel when Bourne-Fuller Company merged with other companies in 1930 to form Republic Steel Corporation. At the time of his retirement he managed the largest bolt and nut plant under one roof in the United States.

C. P. McCabe has been made works manager of Republic Steel Corporation's bolt and nut division. Mr. McCabe has had a varied career with Republic covering the past 15 years. He was first employed at Republic's Ideal Foundry division, later at the Union Drawn Steel division plants in Gary, Indiana, Massillon, Ohio, and Hartford, Connecticut; as an industrial engineer with the Berger Manufacturing division in Canton, Ohio; and as works manager of Republic's Culvert division in Canton. He was made assistant works manager of the bolt and nut division in April 1944.

Mr. McCabe was born in Troy, New York in 1907 and educated in the public schools of Schenectady, New York, studied as an apprentice tool and die maker with the General Electric Company and as a result of this latter experience attended Pratt Institute of Technology in Brooklyn, New York where he was graduated with a degree in mechanical engineering.

W. G. Holt was appointed assistant works manager of the bolt and nut division of Republic Steel Corporation. Mr. Holt has been a Republic employee since 1934. For a period previous to that time he had worked for the Trumbull Steel Company in Warren in the bar mill and hot and cold strip mills. He came to the bolt and nut division in 1942 as superintendent of plant protection and several months ago was made superintendent of the bar mill at the bolt and nut plant.

Eugene B. Mapel has been made supervisor of education and training of Carnegie-Illinois Steel Corporation. First employed by this U. S. Steel subsidiary in 1936, Mr. Mapel formerly served as supervisor of administration planning, prior to which he held the position of manager of sales personnel and served in various capacities in industrial relations work both here and in Gary, Indiana, where he was employed at Carnegie-Illinois sheet and tin mill as director of training immediately preceding his transfer to Pittsburgh in 1940.

E. M. Sarraf was appointed Cleveland district sales manager of Harbison-Walker Refractories Company. Mr. Sarraf has been assistant district sales manager in the Cleveland territory for the past year. He started with the company in its laboratories in 1926 but later devoted his time to the technical department until 1935 when he entered sales in the Harbison-Walker Cleveland offices.

For Economical Material Handling

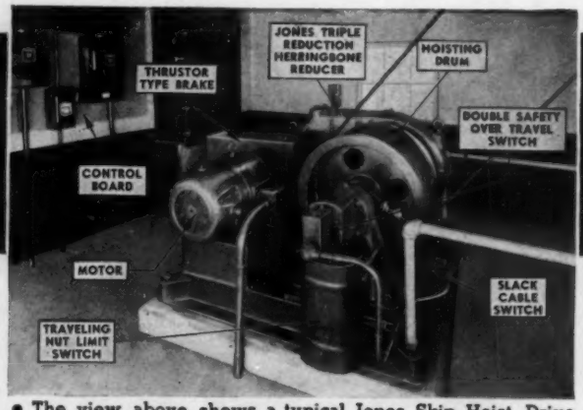
JONES SKIP HOIST DRIVES

FOR speedy operation, reliable service and over-all economy the Jones Skip Hoist Drive has made a name for itself in a wide variety of material handling service. These skip hoist drives are built as complete units by the Jones organization in several types with base to take any motor specified by the purchaser. They are equipped for all the modern protective devices such as cam or nut type limit switches, solenoid or disc type brakes and slack cable switches. The drives are single, double, or triple reduction Jones Herringbone Speed Reducers, built to stand up under the many years of pounding that a skip hoist drive has to take. The shafts are supported in roller bearings, with rolling action, rack generated gear and pinion teeth to insure easiest possible starting with low starting-peak loads. All reducer bearings and gears are automatic oil-bath lubricated.

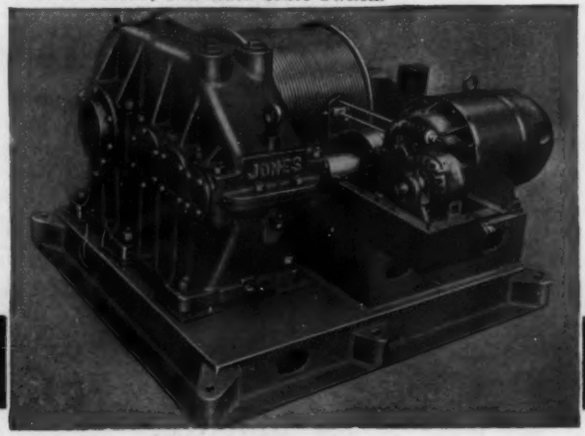
The Jones organization has an extensive file of information on skip hoist drive problems and will be pleased to work with you on any problems involving such applications.

W. A. JONES FOUNDRY & MACHINE CO.
4431 Roosevelt Road, Chicago, Illinois

Jones
HERRINGBONE—WORM—SPUR—GEAR SPEED REDUCERS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES
ANTI-FRICTION PILLOW BLOCKS • PULLEYS
FRICTION CLUTCHES • TRANSMISSION APPLIANCES



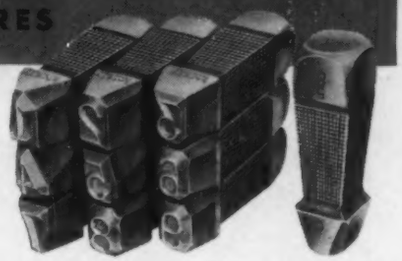
• The view above shows a typical Jones Skip Hoist Drive installation while the view below shows one of the Jones units equipped with traveling nut type limit switch, motor actuated brake, and slack cable switch.



For Maximum Safety in Stamping—

"SAFETY" Wedge Grip

STEEL LETTERS AND FIGURES



- No mushroom
- No spall
- 25% to 50% more service
- More Safety!
- Pat. No. 2,089,794

Perfect balance . . . Knurled sides not only assure *positive* grip with "Wedge Grip" to give clearer, deeper impressions—but also lessen severity of extra heavy stamping. Characters available from 1/16" to 1"

Write for Bulletin J-547

M.E. CUNNINGHAM CO.
SAFETY STEEL STAMPS

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CRANE BUILDERS Since 1903

BEDFORD CRANES

Capacities 5 to 150 Tons

Designed and Engineered to Meet Your Requirements

Any Span or Lift
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ELECTRIC OVERHEAD TRAVELING CRANES
GANTRY CRANES • STEEL DERRICKS
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BEDFORD, INDIANA
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Gray Iron Castings

NO NEED

for Drip Pans

WITH

NON-FLUID OIL

TRADE MARK REGISTERED

Overhead motors don't need drip pans when lubricated with drip-less NON-FLUID OIL. What's more important — you avoid oil-soaked windings so get protection from motor burn-outs caused by short circuits. Oil and application costs are reduced, too, because NON-FLUID OIL lasts longer, lubricating constantly until entirely used up.

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N. Y. & N. J. LUBRICANT CO., Dept. IS
292 Madison Avenue, New York 17, N. Y.
Please send me testing sample of NON-FLUID OIL to be used in the following machinery:

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Company.....
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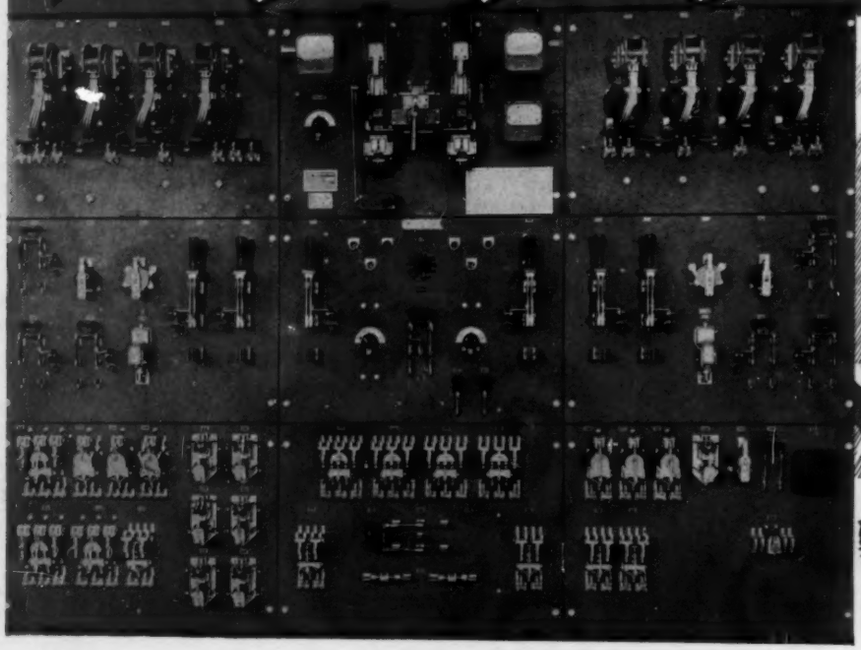
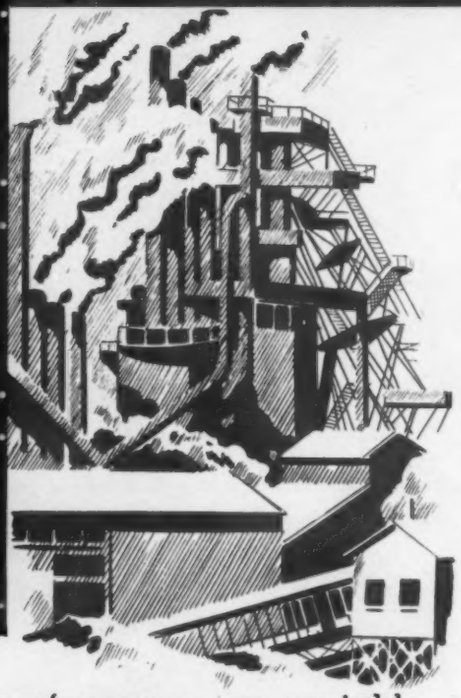
City.....State.....

FREYN-DESIGN CLARK-BUILT BLAST FURNACE SKIP-HOIST CONTROL





● This Freyn-Design Clark-Built Blast Furnace Skip-Hoist Control incorporates many new operating and construction features. Complete details upon request.

The continuous heavy-duty of Blast Furnace Skip-Hoist operation is complemented by Clark Heavy-Duty Control apparatus, which has won, by reliable performance, an enviable position in Mill Duty.

Specific special operations successfully engineered by Clark give credence to the slogan:

"Everything under Control"

Experienced Clark engineers are at your service in Mill Control problems.

THE CLARK CONTROLLER CO.

EVERYTHING UNDER CONTROL • 1146 EAST 152nd STREET, CLEVELAND 10, OHIO

MORGANITE POINTERS
on better brush performance—

No. 4-Bedding Brushes

Bedding new brushes to fit the contour of the commutator or ring is essential to good commutation:
(a) Mount the brush in its holder and apply moderately heavy spring pressure. Place a piece of sandpaper between the brush and commutator or ring and draw it back and forth until the brush assumes the proper curvature. Then for:
(b) Radial and Trailing brushes, finish bedding with fine sandpaper drawn only in direction of rotation.
(c) Reaction brushes, finish with fine sandpaper drawn only against rotation. Slightly bevel the leading or entering edge of the brush.
(d) Finally, blow and wipe away all grit from brush, holder and brush rigging.
Tedious brush replacement can be minimized by installing long life Morganite grades.

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REGISTERED TRADE MARK
CARBON BRUSHES
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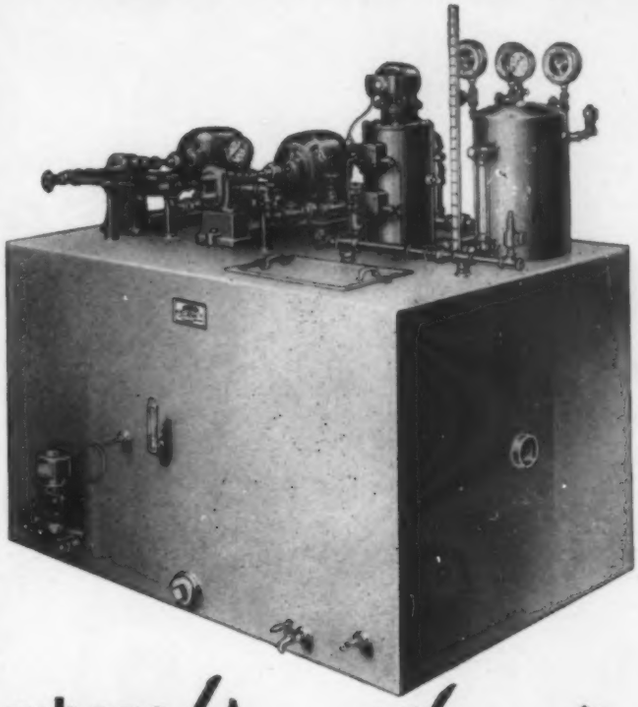
BOWSER
ESTABLISHED 1885
LUBRICATING SYSTEMS
FOR STEEL MILLS
and Other Industrial Plants



where "Know How" REALLY COUNTS

Nearly a half century of specialized engineering and field experience is concentrated in a Bowser Lubricating System.

The flexibility of Bowser lubricating equipment permits exact adaptation to a great many different types of production machinery in steel mills, paper mills and other basic plants.

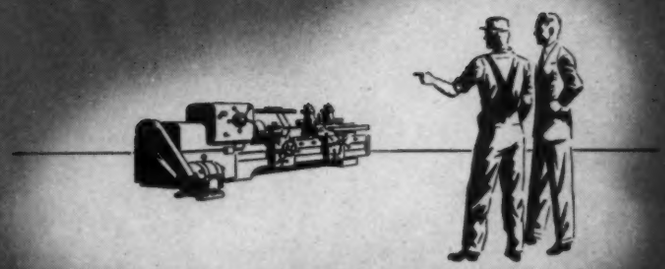
Observation of these installations through the years has conclusively established the dependability and efficiency of Bowser Lubricating Systems.

Bowser Engineers are at your service. You are invited to write, wire or telephone.

BOWSER, INC.,
1314 Creighton Avenue, Fort Wayne 2, Indiana

LIQUID CONTROL SPECIALISTS SINCE 1885

Ask your repairman what he thinks of Crocker-Wheeler protected-type motors



Here is an easy test of motor quality: Ask the man who has to keep your motors in running order.

You will find that the repairman has a very high regard for Crocker-Wheeler motors BECAUSE *he has had so few of them to repair.*

Crocker-Wheeler Protected-Type motors are recommended for use—

- WHERE THERE IS DRIPPING LIQUID
- WHERE THERE ARE FALLING CHIPS
- WHEN INSPECTION VISITS ARE FEW AND FAR BETWEEN
- FOR ALL GENERAL PURPOSE APPLICATIONS . . . HORIZONTAL, VERTICAL OR WALL MOUNTED.

Designed for the tough jobs, these motors are available in standard ratings, from 1 to 1,000 hp.

Ask for full information.

Quality Motors and Generators Since 1888

TAKE THE HEADACHE OUT OF BUYING AND SPECIFYING MOTORS

Ask for your FREE copy of this new 8-page price list. Gives prices, weights, dimensions of all the most commonly used motors, in standard ratings up to 75 hp:

SQUIRREL-CAGE MOTORS: *Protected-Type, Totally Enclosed Non-Ventilated, Totally-Enclosed Fan-Cooled, Explosion-Proof, Splashproof;* **WOUND-ROTOR MOTORS; DIRECT-CURRENT MOTORS:** *Constant-Speed, Adjustable-Speed.*

Also includes additions for bases, flexible couplings and control. Send for your copy today. CW-21

CROCKER-WHEELER
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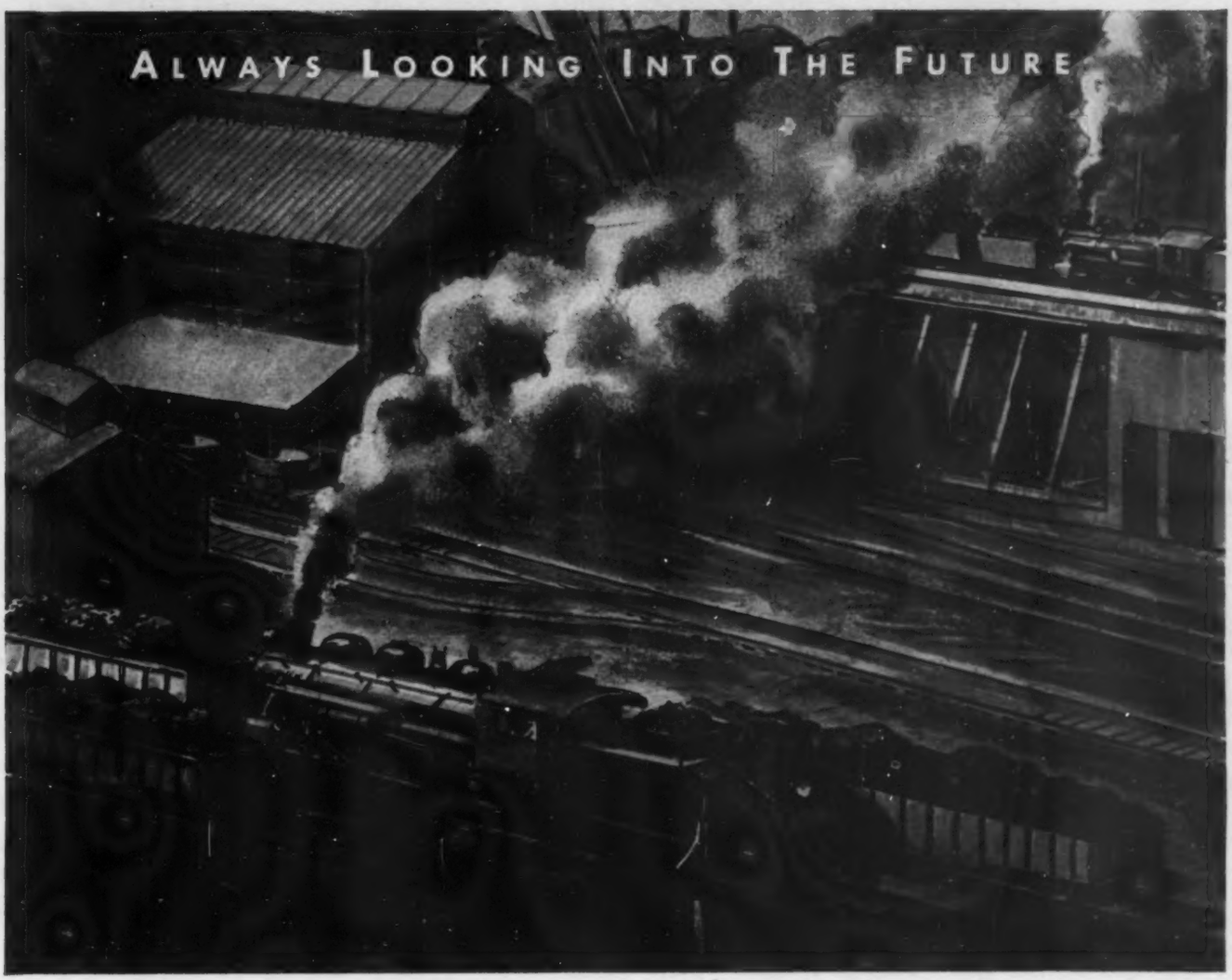
CROCKER WHEELER

ELECTRIC MANUFACTURING COMPANY, AMPERE, N. J.

A Division of Joshua Hendy Corporation

Branch Offices: Boston, Chicago, Cincinnati, Cleveland, Los Angeles, New York, Philadelphia, Pittsburgh — Representatives in Principal Cities.



a new plant for producing oxygen in tonnage quantities

The first plant designed for the commercial production of low purity oxygen in tonnage quantities is now nearing completion. It was designed by Air Reduction and is being installed to supply oxygen to a steel plant for metallurgical purposes. Operation of this plant will provide accurate determination of manufacturing procedures in producing such oxygen, and allow exploration of large scale applications of this new product to iron and steel manufacture.

The giant steel industry is one of the important fields in which the use of tonnage oxygen is being studied for the purpose of speeding production and reducing manufacturing costs.

This is another outstanding example of Airco's policy of pioneering time-saving and product-improving processes that are useful to industry. The experience and facilities of our Technical Sales and Research Divisions are at your disposal in applying Airco techniques to your manufacturing problems.

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If you are interested in obtaining further information, please address: Technical Sales Division, Air Reduction, 60 East 42nd Street, New York 17, N. Y.

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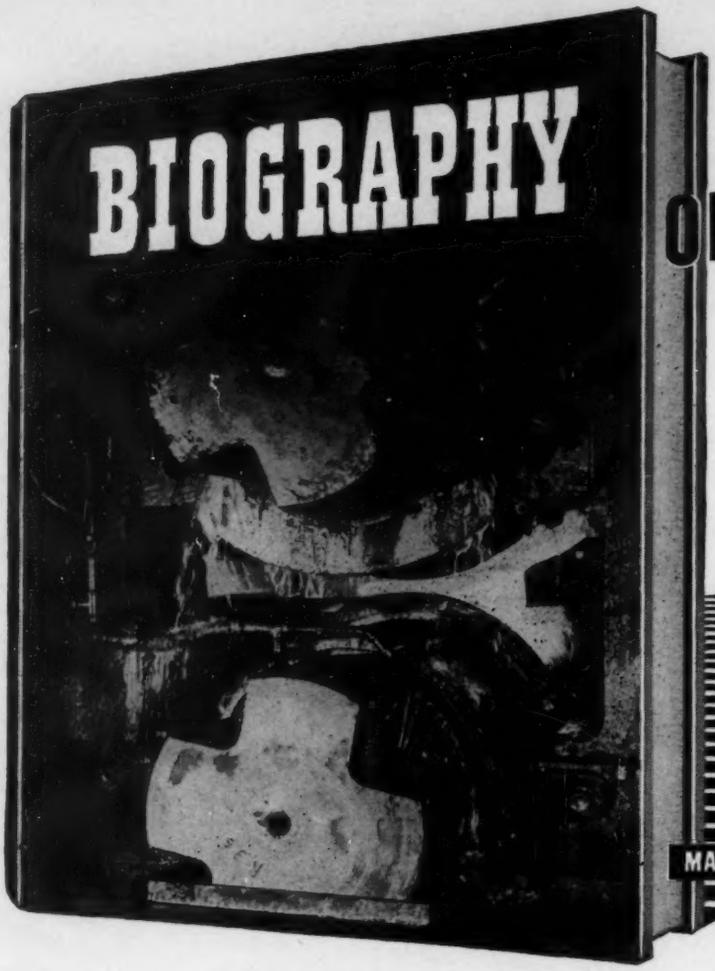
Originators of Modern Oxyacetylene Flame and Electric Arc Methods For ALL Industry



OF N·B·M #200 BRONZE BEARING

MARCH, 1946:

On a prominent 44" Blooming Mill which averaged 85,000 tons on either babbitt or fabric, this bearing was put in trial service on the drive side, paired with a babbitted steel shell on the loose side.

AUGUST, 1946:

The bearing was pulled out for inspection. Despite this handicap of uneven wear, it had rolled 250,000 tons with only 5/16" wear.

FEBRUARY, 1947:

Tonnage now 350,000; some machine work done on bearing.

APRIL, 1947:

This N-B-M #200 Bronze Bearing had rolled almost 500,000 tons — still going strong!

It pays to switch to N·B·M Bearings. May we show you more detailed case histories?

N·B·M BRONZE AND COPPER CASTINGS

BLAST FURNACE COPPER CASTINGS • ROLL NECK BEARINGS • SLIPPERS HOUSING NUTS • MACHINERY CASTINGS • BABBITT METALS • ACID RESISTING CASTINGS • PHOSPHORIZED COPPER

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AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
PITTSBURGH • NEW YORK

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PLANT CLOSED
FUEL SHORTAGE
LAST WINTER
Avoid these costly shutdowns
INSTALL NOW
For next winter's critical time
NORTH AMERICAN
DUAL-FUEL BURNING SYSTEMS
FOR GAS AND OIL
● Switch fuel without any piping changes.
● Automatic fuel-air ratio control.
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● There is a North American Factory-Trained Engineer in your district.
THE NORTH AMERICAN MANUFACTURING COMPANY
CLEVELAND 5, OHIO

"SUPEREX sure stands up!

...You can take my word for it. I've used it behind refractory linings for over 20 years!"

SO SAY steel men everywhere. Oil men, too—in fact, practically everyone who handles high temperature equipment. You can't beat Superex as a block insulation for temperatures up to 1900 F. That's why it's behind more refractory linings than any other block type insulation.

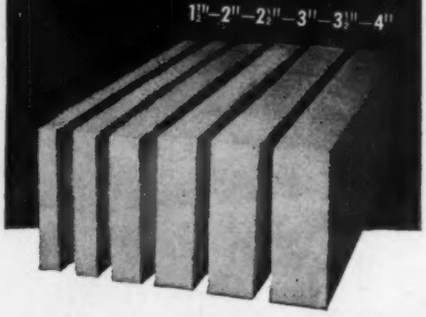
These seven reasons give the Superex story in a nutshell:

1. **Low Thermal Conductivity**—Superex is made from specially selected calcined diatomaceous silica, bonded with asbestos fibre—presenting a formidable barrier to the passage of heat.
2. **High Heat Resistance**—J-M Superex Blocks safely withstand temperatures up to 1900 F. without deterioration.
3. **Lightweight**—Approximately 24 lbs. per cu. ft.
4. **High Physical Strength**—Withstands vibration and other physical abuse encountered in normal service. Approximately five tons pressure per square foot are required to compress Superex ⅛ inch.
5. **Permanent Efficiency**—Superex maintains high thermal efficiency indefinitely—will not disintegrate in service for which recommended.
6. **Quick Application**—The convenient sizes and lightweight of Superex assure fast, economical installations.
7. **Easy Cutting and Fitting**—Superex is easily cut with an ordinary knife or saw for fitting around openings or irregular surfaces.

Special shapes and curved blocks—in addition to the 6 standard thicknesses illustrated—can be supplied. Write Johns-Manville, Box 290, New York 16, N.Y.

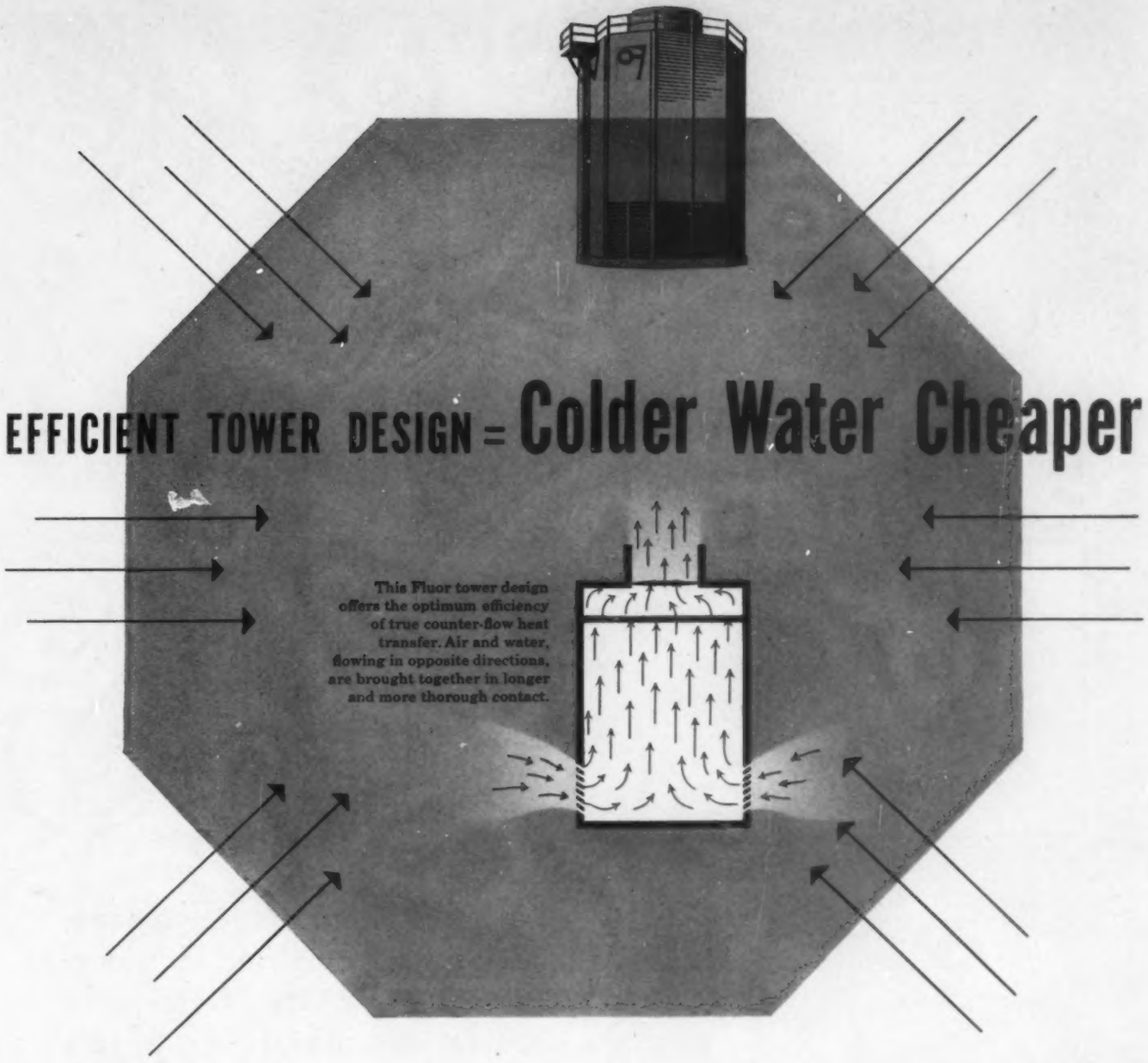
JOHNS-MANVILLE JM PRODUCTS

Superex blocks are finished in various standard sizes and thicknesses.



JOHNS-MANVILLE *First in* INSULATIONS

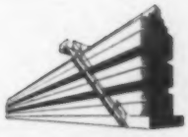
EFFICIENT TOWER DESIGN = Colder Water Cheaper


This Fluor tower design offers the optimum efficiency of true counter-flow heat transfer. Air and water, flowing in opposite directions, are brought together in longer and more thorough contact.

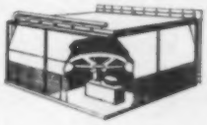
Cheaper? Yes, and here's why: Exhaustive field tests reveal the presence of "dead corner areas" in the conventional induced draft cooling tower, which seriously impair performance.

The new octagonal design of the Fluor "Counterflo" Tower not only eliminates stagnant corner areas, but provides a greatly increased intake area from six sides, thus assuring more uniform air distribution within the tower.

Add to this efficient tower design such other Fluor firsts as the patented upspray "Spirodome" water distributing system, proper design and arrangement of grid decking to assure longer air-water contact, fan and gearing developed to give long service life, and rigid time-resistant construction throughout—and you'll find that they all add up to lower operational costs—which means colder water cheaper!



Fluor areator atmospheric cooling towers are recommended where conditions make this type most practical.



The Fluor Fin-Fan cooling unit has a wide range of utility throughout industry.

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PRODUCTS : *Cooling Equipment, Mufflers, Gas Cleaners, Pulsation Dampeners*

SERVICES : *Designers and Constructors of Refinery, Chemical and Natural Gas Processing Units*

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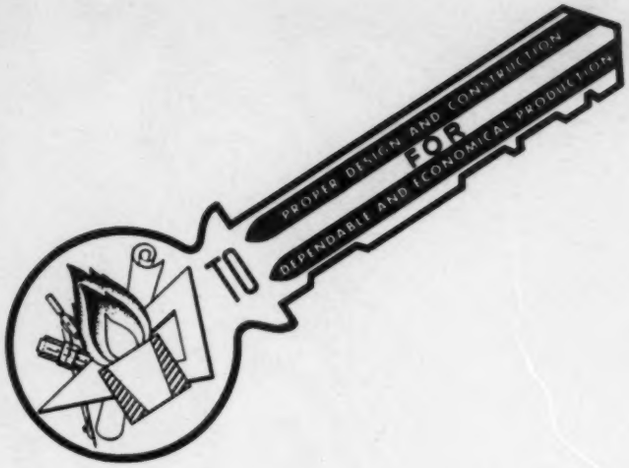

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Loftus Designs and Engineers Complete Plants and Individual Furnaces for the ferrous or non-ferrous industries - From the Open Hearth to the Heating Furnaces for the final rolling - Then from the metal stock to the Heat Treating Line. The Loftus organization serves the metallurgical field from melting and refining to the finished heat-treated product.

610 SMITHFIELD ST. LOFTUS ENGINEERING *Corporation* PITTSBURGH, PA.

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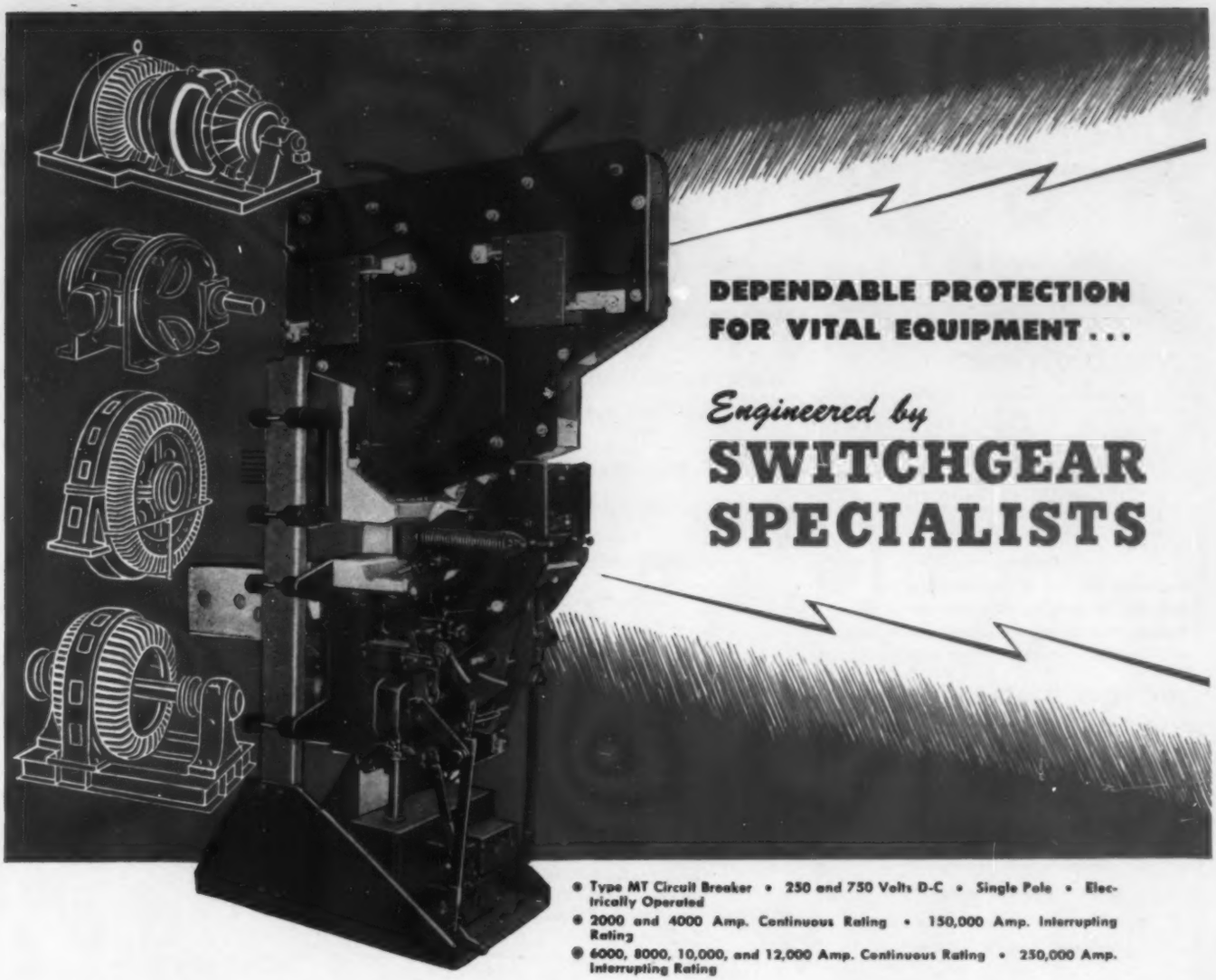

DEPENDABLE PROTECTION FOR VITAL EQUIPMENT...

Engineered by

SWITCHGEAR SPECIALISTS

- Type MT Circuit Breaker • 250 and 750 Volts D-C • Single Pole • Electrically Operated
- 2000 and 4000 Amp. Continuous Rating • 150,000 Amp. Interrupting Rating
- 6000, 8000, 10,000, and 12,000 Amp. Continuous Rating • 250,000 Amp. Interrupting Rating

PROTECT your vital power machinery from the hazards of electrical disturbances more dependably, more efficiently with the I-T-E Type MT Circuit Breaker. The MT helps you avoid expensive repairs, replacements, and production shutdowns because of electrical disturbances; and cuts operating costs by reducing necessary maintenance and attendance.

The quick acting MT interrupts extremely heavy direct-currents in about 1¾ cycles (60 cycle basis) at 25% to 100% of interrupting capacity. All tripping devices are direct acting and instantaneous; short circuits are cleared rapidly and dependably. The valuable *Rate-of-current-rise Trip* distinguishes between a useful load of high value and a dangerous fault current, and trips the breaker before the danger peak is reached—preventing possible damage to cables and connected equipment. The MT is electrically and mechanically trip-free on overcurrent, and trips immediately when closed on a fault.

Ruggedly constructed for heavy duty, the MT main contacts are solid blocks of copper with ample cross section to carry rated currents. Pure silver inserts keep contacts free from oxidation and overheating. Secondary contacts protect the main contacts from arcing damage.

The MT is normally built in two styles; one for panel mounting, the other for pedestal mounting. Truck mountings can also be furnished, if desired. Each style has the same rugged frame of hot-rolled steel, welded into a sturdy support unit.

Complete technical information on the I-T-E Type MT Automatic Reclosing Circuit Breaker is contained in illustrated catalog 2201. Send for your copy. *The I-T-E representative in your locality will be glad to advise you on applying the MT—and other I-T-E protective Switchgear—to your electrical distribution system. Use his services without obligation.*

I-T-E

MILL TYPE SWITCHGEAR

The Leader In Technical Excellence

I-T-E CIRCUIT BREAKER CO., 19TH & HAMILTON STS., PHILADELPHIA 30, PA.—31 OFFICES IN UNITED STATES AND CANADA

SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • AUTOMATIC RECLOSING CIRCUIT BREAKERS • HIGH SPEED CIRCUIT BREAKERS

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AN *IRON and STEEL ENGINEER* SERVICE TO THE STEEL MILL OPERATORS

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CLEVELAND DISTRICT

HARRY J. FISHER AND ASSOCIATES
635 Ferguson Building
CLEVELAND 14, OHIO
Phone: MAin 0810
Representing:
Clark Controller Company
Lapp Insulator Company, Inc.
Pennsylvania Transformer Company
Branch Offices in Youngstown and Akron

PITTSBURGH DISTRICT

ROBERT E. BROWN CO.
Room 412, Jones Law Building
Pittsburgh, Pa.
ATlantic 2142
Representing electrical manufacturers to Pittsburgh industry.

PITTSBURGH (Continued)

PATTERSON-EMERSON-COMSTOCK, INC.
ENGINEERS AND CONSTRUCTORS
Specializing in Steel Mill Construction
313 E. Carson Street
Pittsburgh 19, Pa.
Phone EVerglade 9800

W. G. KERR CO.
520 Oliver Building PITTSBURGH, PA.
Foote Brothers — Gears and Speed Reducers
Reeves Variable Speed Drives
Thomas Flexible Couplings
Telsmith Crushers
Phone: ATlantic 4254

ROLLING MILLS and EQUIPMENT
FRANK B. FOSTER, INC.
2217 OLIVER BUILDING PITTSBURGH 22, PA
Cable Address "FOSTER" Pittsburgh

EDGAR M. MOORE & CO.
502 Renshaw Building
PITTSBURGH 22, PA.
Transformers – Timers – Cable Take-up Reels
Resistors and Rheostats – Selenium Rectifiers
Pumpless Blow Torches

DISPLAY CLASSIFIED ADVERTISING RATES
All displayed classified advertising is sold in multiples of one inch at the flat rate of $8.00 per column inch. Minimum insertion is one inch. Maximum insertion is one column, 10 inches deep, or two columns, 5 inches deep.

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All undisplayed classified advertising is sold at the rate of $1.00 per line. Five line minimum insertion charge. A box number address counts as one line.

Deadline:
All copy must be received by the 20th of the month preceding publication date.

IRON AND STEEL ENGINEER
1010 EMPIRE BUILDING
PITTSBURGH 22, PA.

PITTSBURGH (Continued)

METALLIC RECUPERATORS
(Air Preheaters)
For application to soaking pits, heating, and other types of metallurgical furnaces.
HAZEN ENGINEERING CO.
Park Building PITTSBURGH, PA.

ROBERT T. JOHNSON
District Sales Representative
NORTHERN ENGINEERING WORKS
E.O.T. Cranes – Electric Hoists – Air Hoists
THE HILL-ACME CO.
Alligator Shears – Portable Cranes – Special Machinery
Union Trust Building
PITTSBURGH, PA.
Phone: ATlantic 1535

PENNELL ASSOCIATES
Complete Material Handling Systems
O. R. Heidenrich
Investment Building
PITTSBURGH 22, PA.
ATlantic 6734
ELWELL-PARKER ELECTRIC CO.
Electric Industrial Trucks
NUTTING TRUCK AND CASTER CO.
Warehouse and Floor Trucks
PHILLIPS MINE AND MILL SUPPLY CO.
Heavy Duty Trailers, Skids, Transfer Cars, Skid Dumps
WHITING CORPORATION
Electric Hoists
LIFT TRUCKS, INC.
Hand and Power Driven Lift Trucks
ELIZABETH IRON WORKS
Bridge Ramps for Car Loading
THE BUDA COMPANY
Buda Chore Boy

WHY NOT TAKE ADVANTAGE OF THESE DISTRICT LISTINGS? MANY POTENTIAL CUSTOMERS MAY WANT YOUR PRODUCT OR SERVICE, BUT MAY NOT KNOW WHERE YOU ARE LOCATED.

THE ENGINEERING MART

PRODUCTS
Acid-Proof Materials

Specify SAUEREISEN
ACIDPROOF CEMENTS—COMPOUNDS
FOR
Tanks, Sewers, Stacks, Floors
Technical cements for all purposes.
Send sketches or samples
Sauereisen Cements Company · Pittsburgh 15, Penna.

BUSINESS OPPORTUNITIES

LINES WANTED!

Manufacturers' Agent wants to add electrical lines in Pittsburgh and Youngstown District. Fourteen years industrial sales experience with wide acquaintance in steel industry. Address Box 1200, IRON AND STEEL ENGINEER, 1010 Empire Building, Pittsburgh 22, Pennsylvania.

POSITIONS VACANT

ELECTRICAL ENGINEER, experienced in design, operation, and maintenance of steel mill machinery. Work in England and Europe for large American manufacturer. Address Box 1201, IRON AND STEEL ENGINEER, 1010 Empire Building, Pittsburgh 22, Pennsylvania.

WANTED

Copies of "THE MODERN STRIP MILL" published by the AISE. If your copy is not being used why not sell it? For details write to IRON AND STEEL ENGINEER, Box 1202, 1010 Empire Building, Pittsburgh 22, Pennsylvania.

News Supplement

(Continued from page 129)

comer among rolling mill goods. Cladmetal is made up of metals bonded together in their pure state. It offers the best qualities of each chosen metal in the composite product. In the rolled sheet one of the metals, on the surfaces, clothes the other beneath. The metals are not alloyed, hence their original qualities are not changed.

Copper can be sandwiched between layers of stainless steel. The resulting cladmetal resists contamination due to its stainless surface and has the added advantage of rapidly and evenly distributing heat due to the natural qualities of copper. These two good qualities in one sheet of cladmetal are useful in many industrial applications as well as in the kitchen. The development program of American Cladmetals also involves cladding of other metals such as aluminum to steel and silver to steel. The company plans to produce six to eight millions lbs of cladmetal annually with the equipment it is originally installing.

DEVICE VENTS INTERNAL TRANSFORMER PRESSURES

▲ A cover-mounted, mechanical relief device that will vent internal transformer pressures caused by electric arcs or overloads more quickly and effectively than is possible by any present device that depends upon the rupturing of a diaphragm is announced by Westinghouse Electric Corporation. Designed to fit any transformer with a 9-in. handhole opening, adapters can be used for larger openings if necessary.

The new relief device will withstand full vacuum when filling the transformer with oil under vacuum on tanks designed for this method of filling. A locking method is also available so that the tank can be pressure tested in the factory or in the field. In most cases the device can be shipped in place on the transformer.

A roller latching arrangement locks the vent tightly closed until the pressure for which the device is set is reached when it trips the vent fully

This device is designed to fit any transformer with a 9 in. hand hole opening.

open. The device can be set for 10 psi and tripping takes place within ½ lb pressure of this setting. A dome over the opening prevents rain from entering the transformer even after operations.

Resetting after operation is simple and requires no replacement parts other than new gaskets that can be made in the field if necessary.

Tests have indicated that the new relief device offers less resistance to escaping gases than diaphragm types of relief devices and, in consequence, pressures within the transformer do not build up to excessive values nor is oil vapor thrown as far when operating.

The mechanical relief device is only 17 in. in diameter and stands approximately 7 in. above the transformer cover. It can be used on new transformers and is small enough in most cases so it can be applied to existing transformers without modifications.

PITTSBURGH STEEL BUYS BLAST FURNACE

▲ Approval of the sale of the government-owned incomplete blast furnace at Monessen, Pennsylvania, to the Pittsburgh Steel Company has been announced by the War Assets Administration. The sale, completed for approximately 97 per cent of the fair value of the facility, includes one of two turboblowers located at the government blast furnace at Cleveland. This blower will be removed from its present location and installed at the Monessen furnace.

FOR TEMPERATURES AND PRESSURES

This is the new Brown *Electr-o-Vane* Control Unit. To users of electric contact control Thermometers and Pressure Gauges, it offers a high degree of control performance never before attained.

A true triumph in control, this electronic unit is not merely an adaptation of a known principle but an achievement in design by which all the shortcomings of similar devices are eliminated.

Added to the Brown Thermometer and Pressure Gauge line, the *Electr-o-Vane* Unit provides a control instrument of unequalled performance. No instrument of this type can equal its dependability in service, its precision in operation or its safety features.

Brown *Electr-o-Vane* Thermometers and Pressure Gauge Controllers are available *at no premium cost*. With all the exclusive features of these instruments, why compromise with less than the best.

A NEW CATALOG (No. 6001) fully describing the operating principle, features and models of the Brown *Electr-o-Vane* Controllers is now available. Write for your copy today—there is no obligation.

The Brown Instrument Company, 4464 Wayne Ave., Philadelphia 44, Pa.
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.
SUBSIDIARY COMPANIES IN TORONTO • MEXICO CITY •
LONDON • STOCKHOLM • AMSTERDAM • BRUSSELS

HERE ARE THE FACTS

The Brown *Electr-o-Vane* Control Unit operates on the principle that when a metal vane is interposed between two oscillator coils in a unique electronic circuit, the oscillations stop. This stopping of oscillations causes the electronic circuit to operate a load relay.

The oscillator coils are the heart of the controller. Brown oscillator coils are molded in bakelite and are thus *moisture-proof*—an exclusive Brown feature. A knife-edge control action is provided that does not drift. Control action is precise. It never varies. It is unaffected by moisture conditions.

Only the circuit used in the Brown *Electr-o-Vane* Control Unit causes an actual stop in oscillations. That is why this is the only instrument of its type providing real *snap action*—an important factor for precision control.

Brown *Electr-o-Vane* Control is contained in a neat, compact unit. It is self-contained, easily removed as a unit and unaffected by dust or dirt.

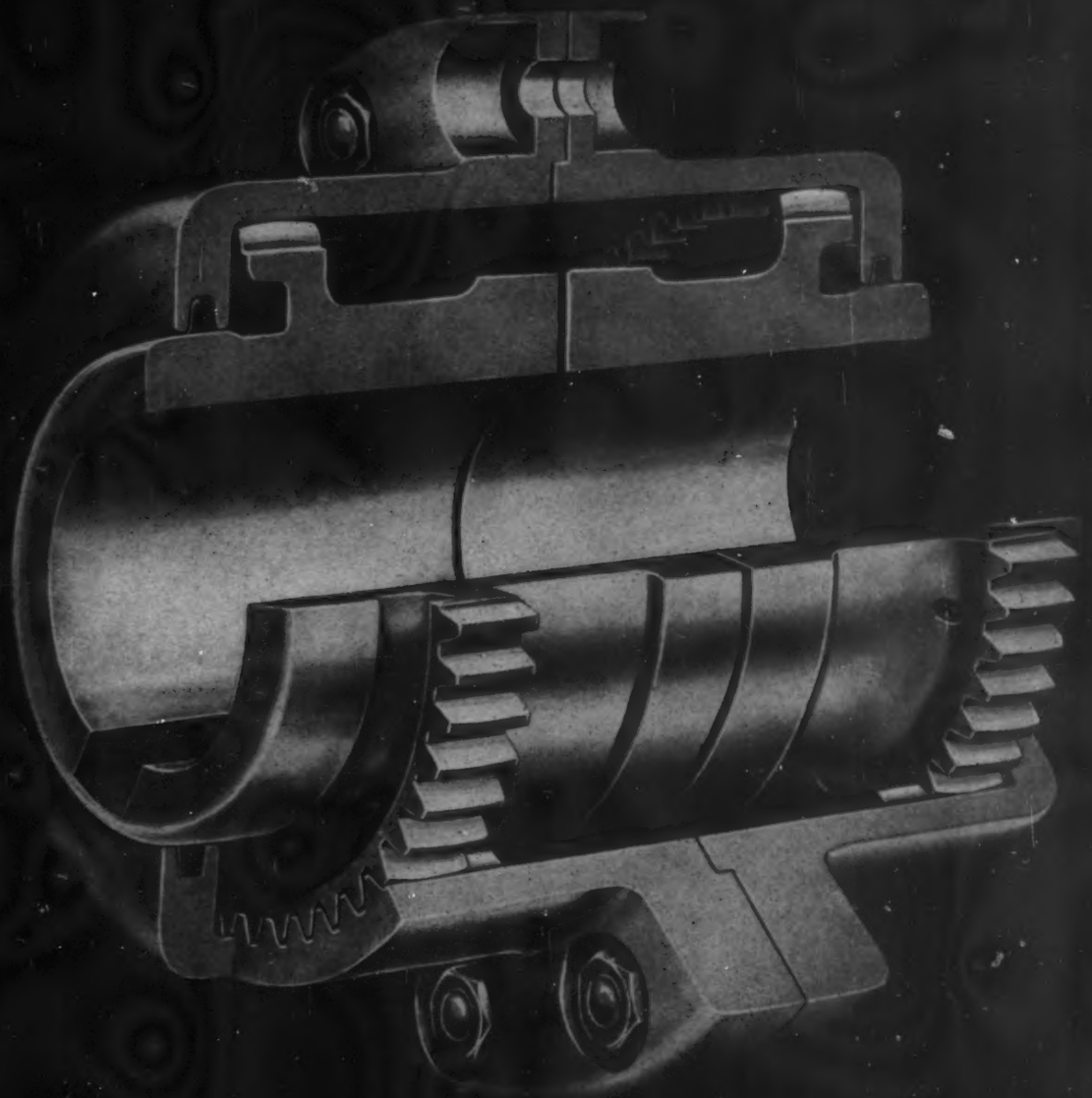
Electr-O-Vane

BROWN

THERMOMETER CONTROLLERS

PRESSURE GAUGE CONTROLLERS

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

SHORT FACTS ABOUT LONG-LIVED CABLE

OKOLITE-OKOPRENE

its OKOLITE insulation

. . . is electrically stable
. . . resists moisture and ozone
. . . operates at 75° C.

its OKOPRENE sheath

. . . resists corrosion
. . . resists oils and acids
. . . is non-flammable

OKOLITE-OKOPRENE

. . . serves up to 5000 volts
. . . manufactured in all sizes
. . . is described in Bulletin OK-1037.
For a copy address The Okonite Company, Passaic, New Jersey.

DIMENSIONAL DATA

OKOLITE · OKOPRENE WIRES AND CABLES

OKONITE insulated wires and cables

Your Everyday Piping Needs Now Filled from Local Stocks

No waiting for most regular items at your Crane Branch or Wholesaler

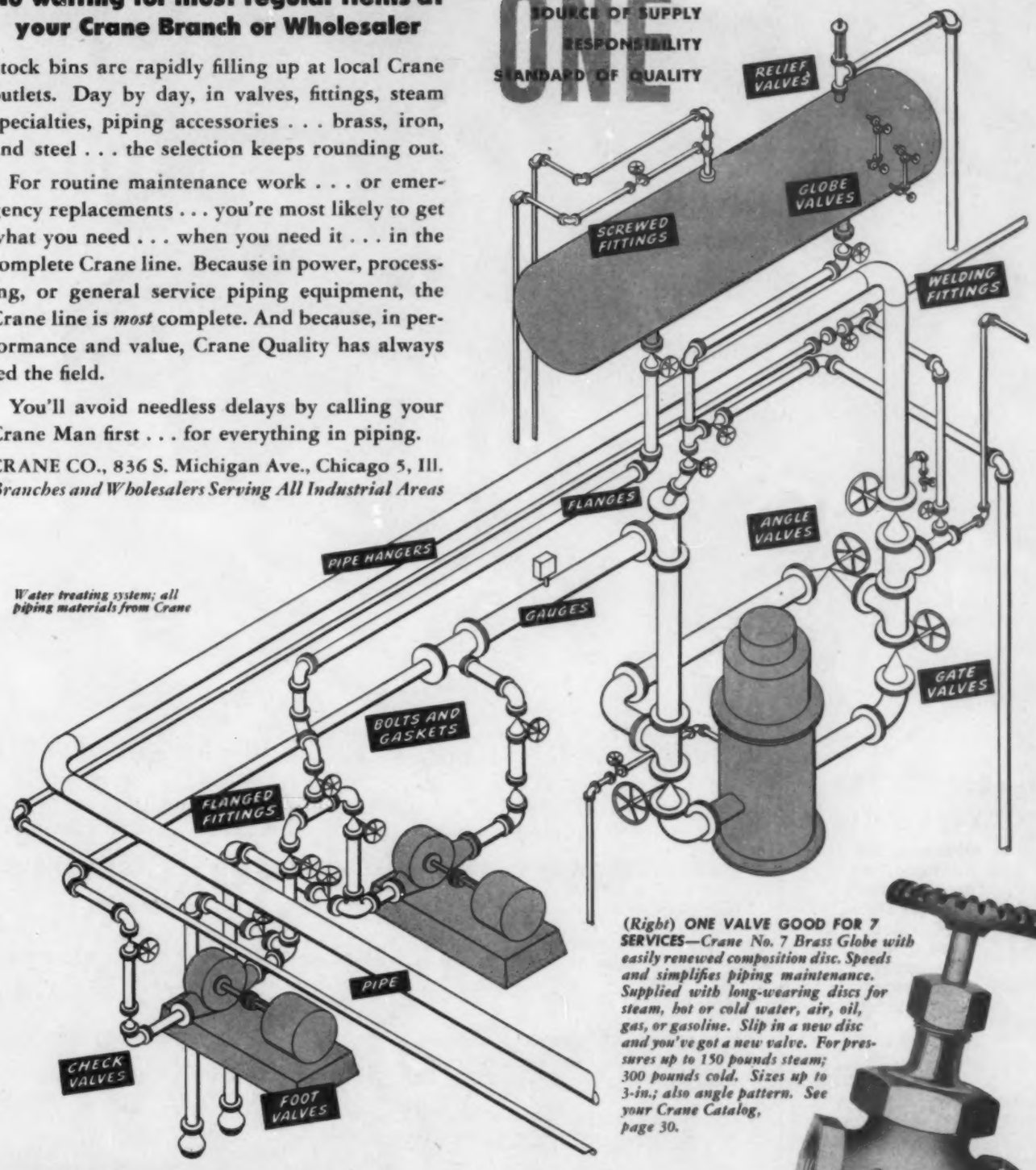
Stock bins are rapidly filling up at local Crane outlets. Day by day, in valves, fittings, steam specialties, piping accessories . . . brass, iron, and steel . . . the selection keeps rounding out.

For routine maintenance work . . . or emergency replacements . . . you're most likely to get what you need . . . when you need it . . . in the complete Crane line. Because in power, processing, or general service piping equipment, the Crane line is *most* complete. And because, in performance and value, Crane Quality has always led the field.

You'll avoid needless delays by calling your Crane Man first . . . for everything in piping.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY



Water treating system; all piping materials from Crane

(*Right*) **ONE VALVE GOOD FOR 7 SERVICES**—*Crane No. 7 Brass Globe with easily renewed composition disc. Speeds and simplifies piping maintenance. Supplied with long-wearing discs for steam, hot or cold water, air, oil, gas, or gasoline. Slip in a new disc and you've got a new valve. For pressures up to 150 pounds steam; 300 pounds cold. Sizes up to 3-in.; also angle pattern. See your Crane Catalog, page 30.*

EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

...to Produce Greater Tonnages at Lower Cost!

BIRDSBORO
Type Rolls

*Birdsboro "30"
Birdsboro "40"
Birdsboro "50"
Birdsboro Metal
*Curoloy
Super Curoloy
Grainloy
Superloy
*Diamondite

FOR:

Blooming
Cogging
Roughing
Semi-Finishing
Finishing

*Patented

You can depend on Birdsboro's Individualized Roll Service. That means Birdsboro Rolls are individually engineered to give you the specific combination of analyses and physicals to do its particular job best.

Whether your problem involves ferrous or non-ferrous metals and regardless of the degree of toughness or hardness required, Birdsboro Rolls assure you of greater tonnages, more accuracy, longer uninterrupted production and less replacement cost. On any roll problem, consult Birdsboro engineers first.

BIRDSBORO STEEL FOUNDRY & MACHINE COMPANY • BIRDSBORO, PA.

BIRDSBORO
ROLLS
Steel Mill Equipment, Hydraulic Presses, Special Machinery, Crushing Machinery, Steel Castings

REPRESENTATIVES:

Pittsburgh Office
Gulf Bldg. Room 1609

Chicago Office
9925-50 Hamilton Ave.

BARRETT-CRAVENS
POWER-OX LIFT TRUCK

DEPENDABLE

POWER

EXIDE-IRONCLAD POWER
AND BATTERY ELECTRIC TRUCKS

The efficient, cost-cutting team that speeds materials handling

You gain all along the line when your materials are handled by electric trucks and Exide-Ironclad Battery Power. This modern efficiency team keeps goods moving in greater volume, and saves time and money all day long.

Exide-Ironclad Batteries are preferred for electric truck service because of their great power and dependability . . . a result of special Exide-Ironclad construction, which is unlike that of any other battery.

One important Exide-Ironclad feature is the positive plate which consists of slotted tubes containing the active material. So tiny are these slots that, while permitting easy access of the electrolyte, they prevent the active material from readily washing away. The results are high power ability, longer life, greater economy and safety.

Write us for a FREE copy of Exide-Ironclad Topics which contains "Case Studies" of material handling problems. It tells how to cut handling costs up to 50% . . . covers latest developments in handling materials from receiving to shipping.

THE ELECTRIC STORAGE BATTERY COMPANY
Philadelphia 32
Exide Batteries of Canada, Limited, Toronto

BARRETT-CRAVENS
POWER-OX LIFT TRUCK

DURABLA

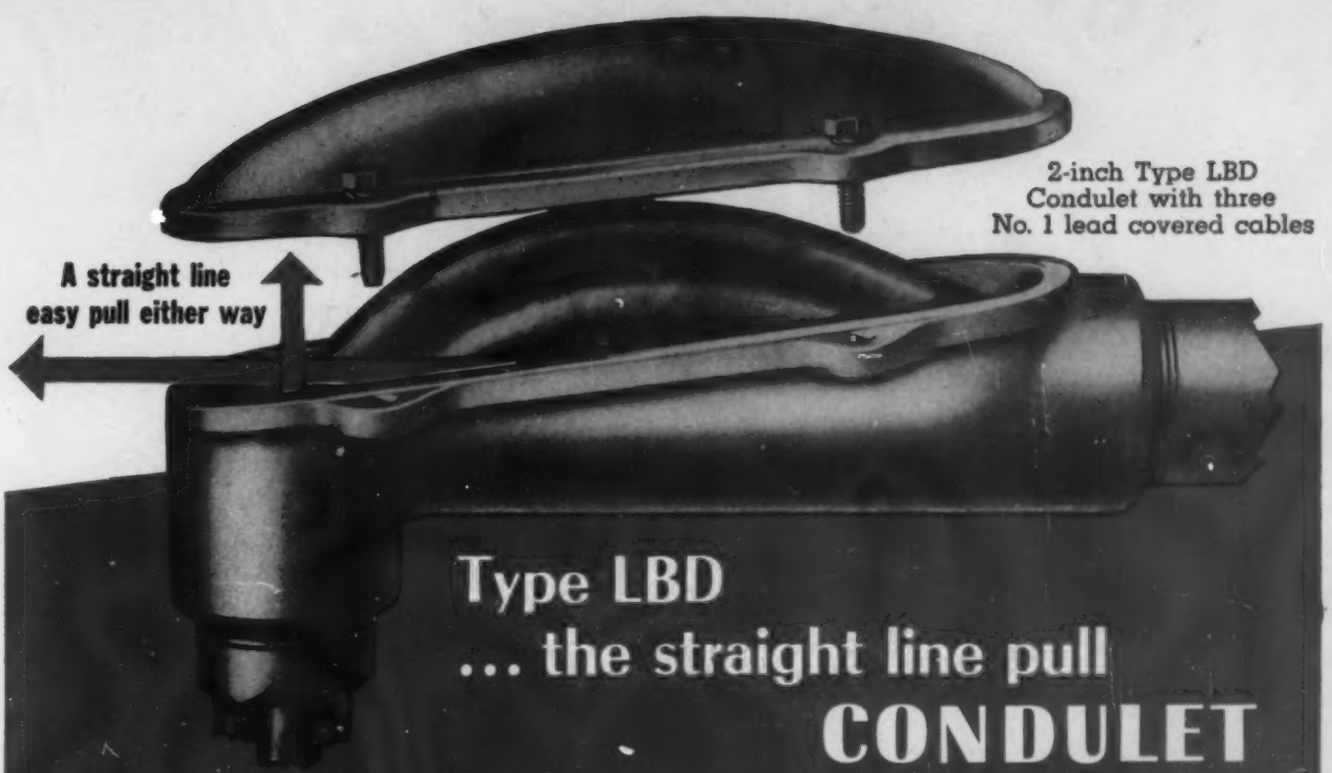
VALVES OPERATE IN ANY POSITION

The positive self-grinding, quick-closing DURABLA VALVE* for Pumps, Diesel Engines, and Compressors is the only valve which operates with equal efficiency and adaptability in any position. Designers and users requiring valve replacement can fit it into those tight inaccessible places with complete confidence in continued efficiency, freedom from any need for more than very infrequent inspection, compact design, and light weight.

Address DURABLA Engineering Department for Information and Bulletin; Reference 7S12

* Patent Numbers 2090486, 2117504

DURABLA MANUFACTURING COMPANY
114 LIBERTY ST. NEW YORK
BRANCHES IN PRINCIPAL CITIES. FOR CANADA REFER: CANADIAN DURABLA LIMITED, TORONTO



2-inch Type LBD
Condulet with three
No. 1 lead covered cables

Type LBD
... the straight line pull
CONDULET
for large or lead covered electrical conductors

(CONDULETS are made only by CROUSE-HINDS)

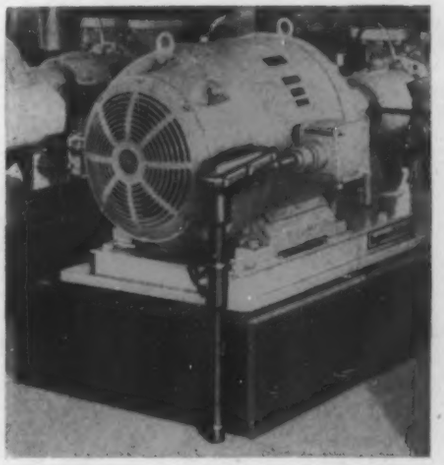
A straight line pull through EITHER hub. Saves time.

Unobstructed pulling space. Easy to manipulate conductors.

Domed cover. Provides extra space to prevent sharp bends that are likely to injure the conductor insulation or sheath.

All sizes. For electrical conduit from ½-inch up to 6-inch.

An Explosion-Proof type is available. Type LBH in sizes from ½-inch up to 3-inch.



A Nationwide Distribution Through Electrical Wholesalers

CONDULETS . . . first in the field and the finest

CROUSE-HINDS COMPANY
Syracuse 1, N. Y.. U.S.A.

Offices: Birmingham – Boston – Buffalo – Chicago – Cincinnati – Cleveland – Dallas – Denver – Detroit – Houston – Indianapolis – Kansas City – Los Angeles – Milwaukee – Minneapolis New York – Philadelphia – Pittsburgh – Portland, Ore. – San Francisco – Seattle – St. Louis – Washington. *Resident Representatives:* Albany – Atlanta – Charlotte – New Orleans – Richmond, Va.
CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

CONDULETS · TRAFFIC SIGNALS · AIRPORT LIGHTING · FLOODLIGHTS

This is a picture of a Link-Belt inspector engaged in assuring the efficient performance of Link-Belt Bearings. This, indeed, is ruthless, uncompromising inspection which greatly magnifies the image of the raceway and compares its profile with the master curve gauge. In the battle against friction, Link-Belt bearing designers and producers ask no quarter, nor do they give one. Link-Belt invites you to put your bearing problems in their hands.

The Link-Belt medium series single row self-aligning ball bearing illustrated here has the following features:

1 Spherical seat compensates for misalignment up to 2½ degrees, or ½" per lineal foot of shaft.

2 Spherical surfaces fully lubricated and protected from dust and dirt, assuring free aligning action throughout life of bearing.

3 Self-aligning grease seals of accurately formed pressed steel and long fiber felt.

4 Outside rotating member develops full flinger action.

5 Unit completely sealed at factory for permanent protection of bearing parts.

6 Knurled cup points firmly lock set screws in place.

7 True flat surface assured for nut pressure surface.

8 Compact, solid housing requires minimum support space. Base spotted for drilling for dowel pins. Elongated bolt holes facilitate alignment and assembly.

9 Ample grease reservoir.

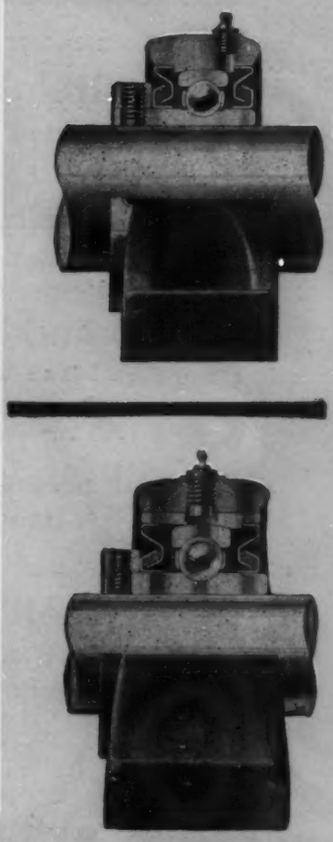
10 Extended inner race distributes bearing load over large shaft area.

11 Double setscrewed collar locks inner ring assembly to shaft.

12 Hydraulic grease fitting conveniently located at 45° from horizontal center-line of bearing.

13 Locking plug equipped with hydraulic type grease lubrication fitting, conveniently located outside and allows axial movement of the cartridge.

14 Steel inner housing, completely assembled with bearing and seals, is free to float in bore of outer housing. Cartridge treated to prevent rust, assuring free axial movement, eliminating heavy thrust loads.

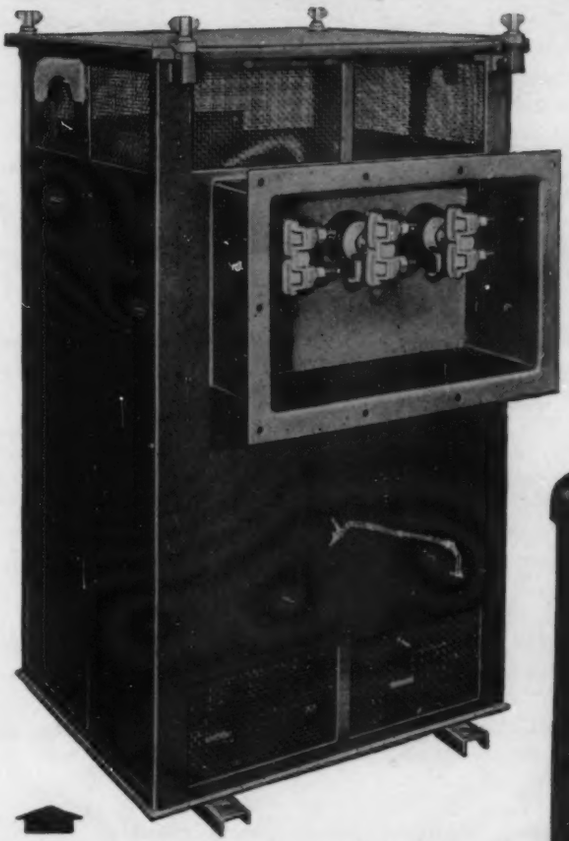


LINK-BELT

BALL and ROLLER BEARINGS

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Houston 2, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

GET THE RIGHT VOLTAGE . . .



A 100 kva two-winding air-cooled transformer, showing typical construction used in the larger units, which are designed for indoor service only.

RIGHT WHERE YOU NEED IT

with Wagner

Air-Cooled Dry-Type Transformers

Do you have electrically driven equipment in your factory, office, store or home that requires higher or lower voltages than your lighting or power circuits provide? Chances are you do. And chances are better that the safest and most economical way to get the right voltage right where you need it is to install Wagner air-cooled dry-type transformers.

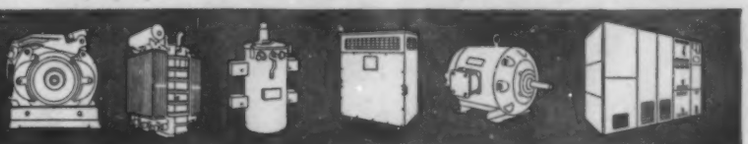
Wagner air-cooled transformers can usually be installed exactly where needed. They do not require special vaults, even in locations where fire hazards are present; this means lower installation costs, and lower insurance rates.

Wagner's complete line of distribution and power transformers also includes air-cooled unit substation transformers in ratings from 100 to 2000 kva. Write for Bulletins TU-180 and TU-181. Wagner Electric Corporation, 6483 Plymouth Ave., St. Louis 14, Missouri, U. S. A.

Typical construction of two-winding air-cooled transformers through 10 kva, and air-cooled auto-transformers through 25 kva. These sizes can be installed indoors or outdoors.

Consult Wagner Engineers on All Transformer Problems

Wagner Electric Corporation
EST. 1891

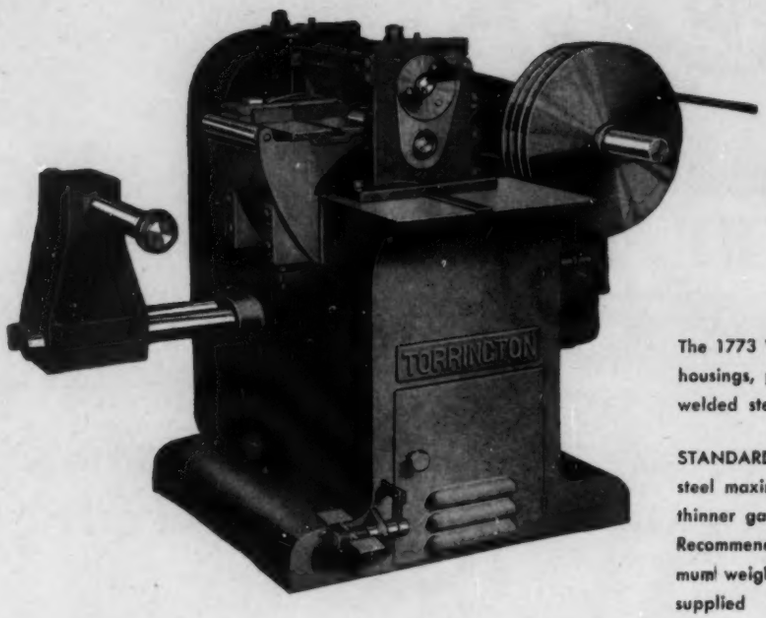


BRIDGE BRAKES • POWER AND DISTRIBUTION TRANSFORMERS • MOTORS • UNIT SUBSTATIONS

ELECTRICAL AND AUTOMOTIVE PRODUCTS

T47-16

A *NEW* WAREHOUSE SLITTER



The TORRINGTON WAREHOUSE METAL SLITTING MACHINE 1773*

IN the field of warehouse metal slitting, a compact, smoothly running, well-guarded slitter is required, which above all may be quickly set up to produce any desired combination of cuts on any gauge of metal within its range.

The Torrington *1773 Warehouse Type Metal Slitting Machine has been especially designed to meet these requirements. Years of experience in building metal slitting machines have been applied to the development of this model, which was first announced at the recent National Metal Exposition. The enthusiastic reception of the 1773 has proved the desirability of the design, and enabled Torrington to commence manufacturing in production lots, which makes possible a highly competitive price.

Detailed specifications and quotation will be furnished upon request.

The 1773 Warehouse Type Metal Slitting Machine is a compact unit. The housings, payoff, winder and motor drive are all mounted on a single welded steel base, reducing floor space to approximately 4' x 6'.

STANDARD CAPACITY—5 cuts (4 strips) .080" non-ferrous or .062" mild steel maximum thickness, or an equivalent number of additional cuts in thinner gauges up to 12" or 18" maximum trimmed width respectively. Recommended minimum thickness .010". Maximum O.D. of coil 20"; maximum weight of coil, 400 lbs. Special supports for heavier coils can be supplied

SPEED—150 F. P. M.

CUTTERS AND CUTTER ARBORS—Cutters (separately quoted) are 5½" diameter, of either alloy tool steel or hi-carbon, hi-chrome steel. Arbors are of steel, 2⅝" diameter, with ½" x ½" key.

ADJUSTMENTS—An exclusive feature is a manual adjustment of the top arbor to compensate for wearing down of the cutters. Simple, manually operated spur gears rotate the eccentric arbor bushing at each housing, providing a total adjustment of 9/16".

GUIDE TABLE—At entry has adjustable side guides, wood wipers with spring to exert tension on the metal, and idle guide roller. 40" metal line.

WINDER—At exit consists of a 2½" diameter winding arbor fitted with 3/32" slot and handwheel for starting strips. Recommended maximum thickness on 2½" diameter arbor is .062".

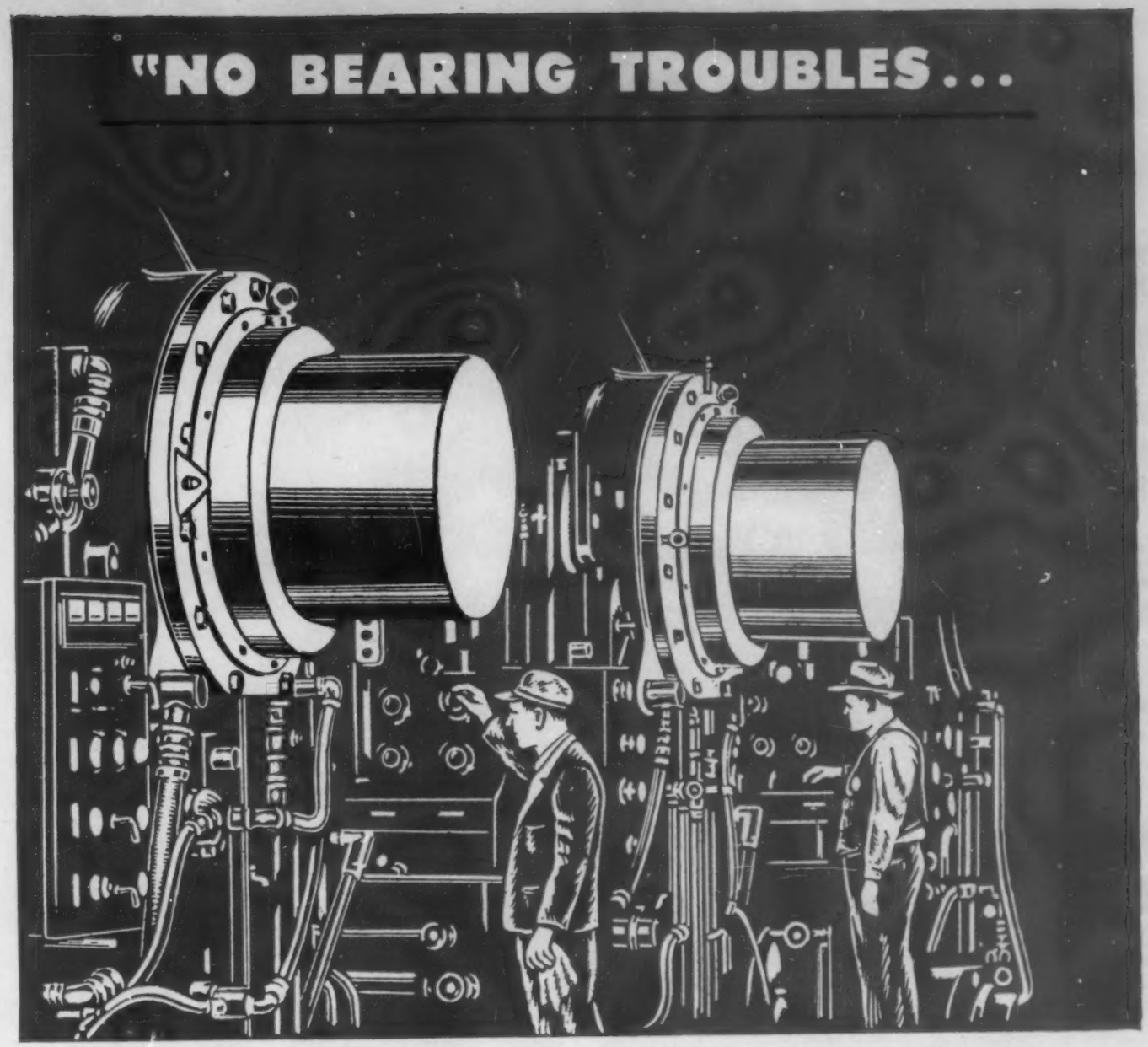
SEPARATOR DISCS — (separately quoted) Hardened and tempered spring steel .055"—.050" thick and 14" or 20" diameter.

DRIVE—Standard make motor, 5 H.P., 1800 R.P.M. Drive to winder through Link leather belt.

***The number "1773" indicates that this is the one thousand seven hundred and seventy-third complete and original design planned on the drafting boards of the Torrington Manufacturing Company. The number of machines built for the metal mills is many times that figure.**

The **TORRINGTON MANUFACTURING COMPANY TORRINGTON, CONNECTICUT**

"NO BEARING TROUBLES...



with Tycol E. P. Lubricants"

"Not a bearing overheated . . .
Service-life doubled . . .
Races undamaged . . .
Better performance . . .
Maintenance costs cut . . ."

—were the statements made recently by a lubricating engineer. "Yet," he went on, "the anti-friction bearings in our plant operate continuously under severe heat and moisture conditions—tremendous loads."

This is one of the many uses of Tycol E. P. Lubricants. For more information call, write, or wire your nearest Tide Water Associated Office.

TYCOL
INDUSTRIAL LUBRICANTS

Boston • Charlotte, N. C.
Pittsburgh • Philadelphia

TIDE WATER ASSOCIATED OIL COMPANY
17 BATTERY PLACE · NEW YORK 4, N. Y.

LUBRICATION—"ENGINEERED TO FIT THE JOB"

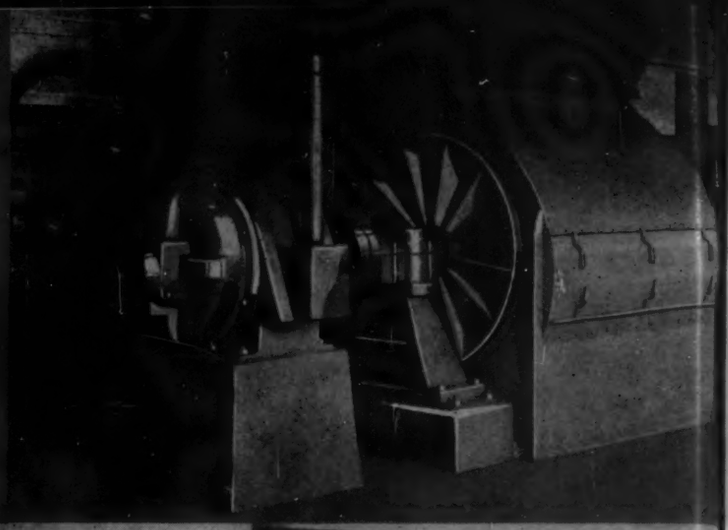
lower power costs

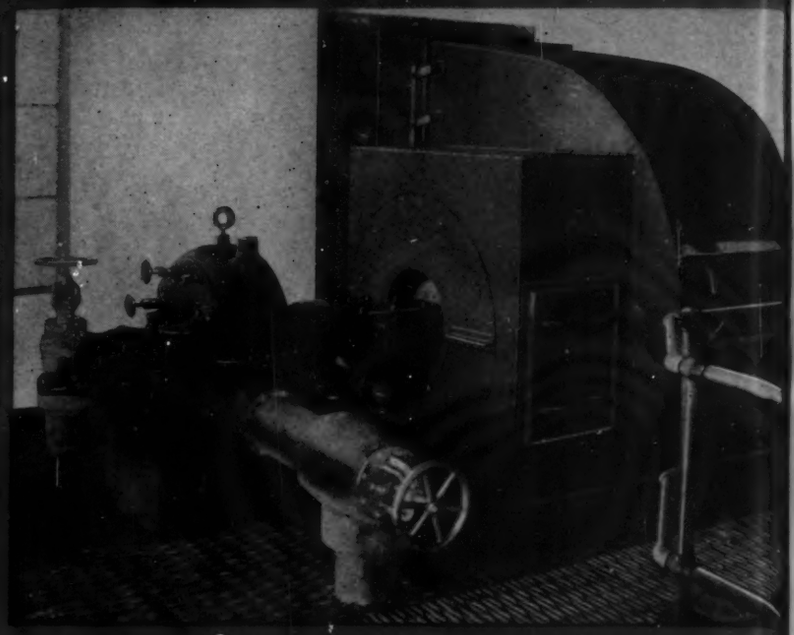
longer fan life

fewer time-outs

shorter time-outs

"Buffalo" draft fans





How to cut down on costly shutdowns due to boiler fan failure?

How to get more efficiency into power production?

These problems which plague power operating men have the continuous attention of "Buffalo" engineers in designing "Buffalo" Draft Fans.

First, structures subjected to greatest wear from ash erosion are built up. Extra thick housing plates are used. Accessibility, too, is built into the design — providing for faster inspection or replacement of parts.

And all "Buffalo" efficiency features are in these fans — the properly proportioned blades, the balanced, vibrationless rotors, the directional inlet vanes, the proven scroll housing. *When you specify "Buffalo" Draft Fans, you are sure of low-cost continuous service with fewer and shorter shutdowns.*

BUFFALO FORGE COMPANY

173 MORTIMER STREET — BUFFALO, NEW YORK

CANADIAN BLOWER & FORGE CO., LTD., KITCHENER, ONT.

WHAT IS *Your* DRAFT PROBLEM?

There is a "Buffalo" Forced Draft, Induced Draft or Cinder Eliminating Fan to solve it, whatever capacity you require. SIMPLY WRITE for full information at no obligation.

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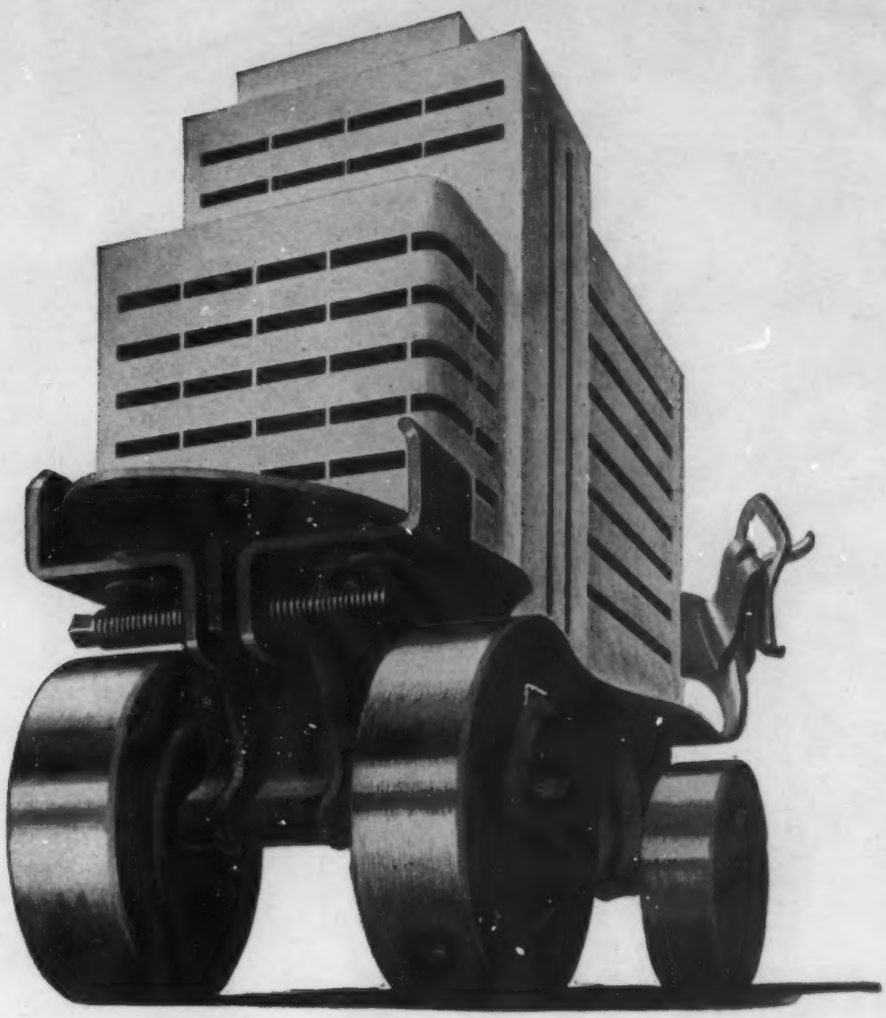

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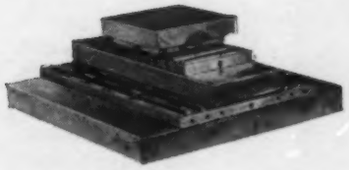

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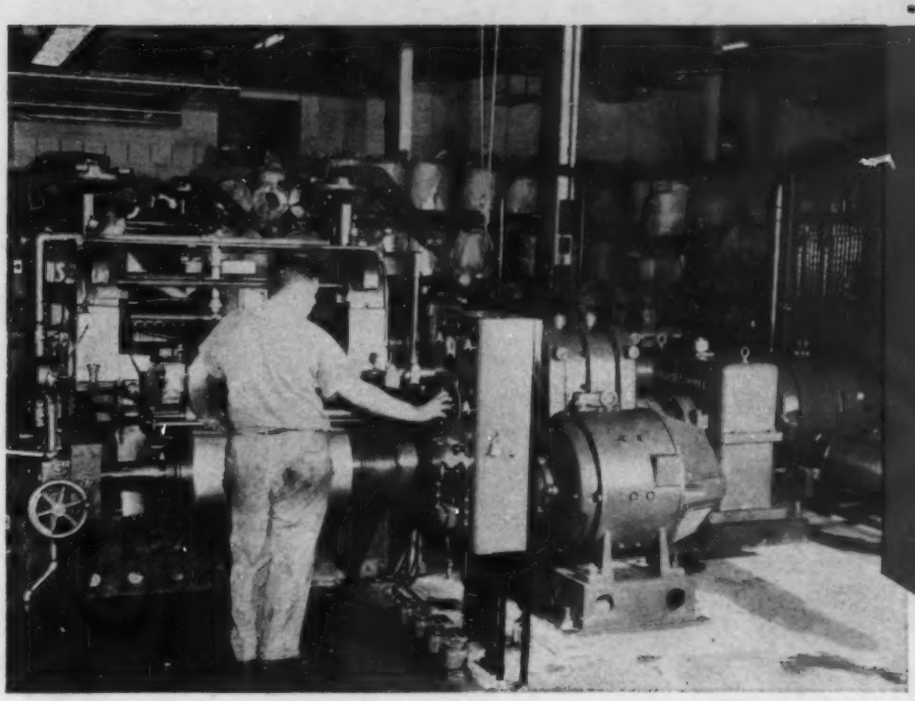

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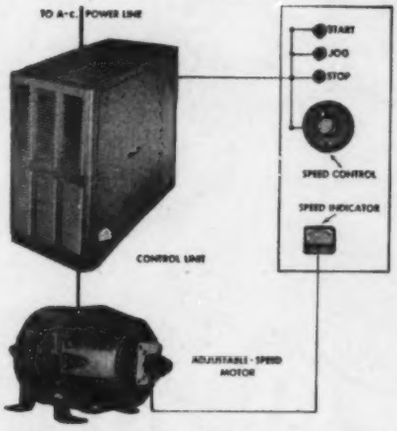

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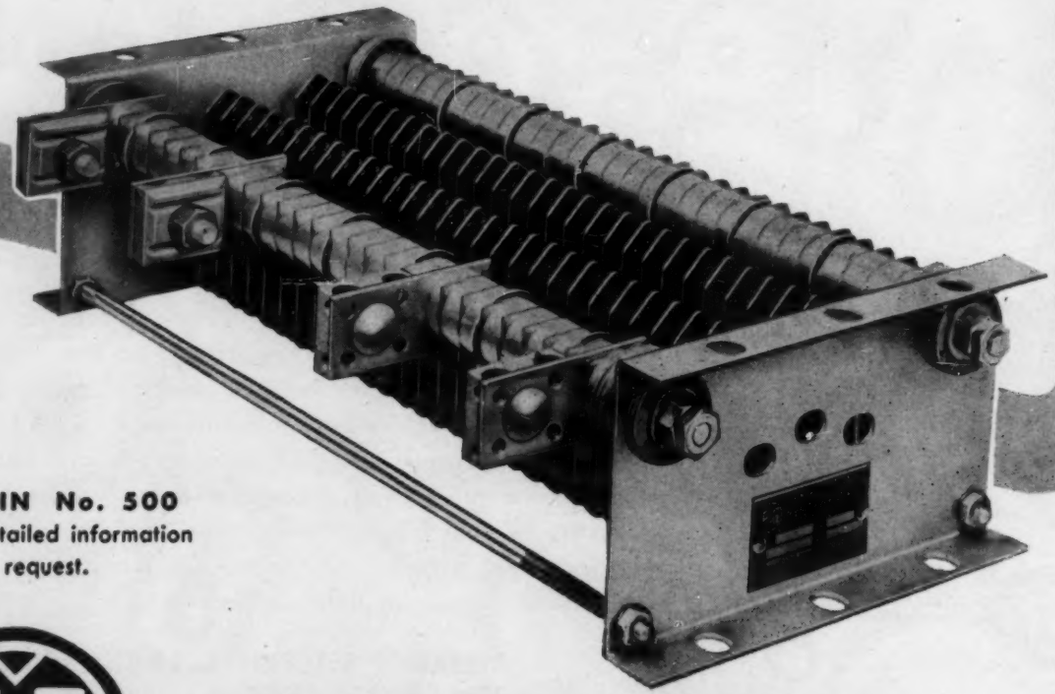

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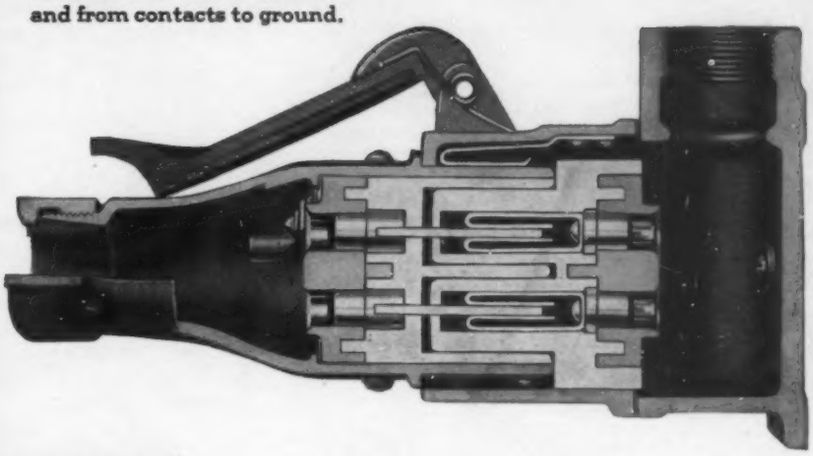

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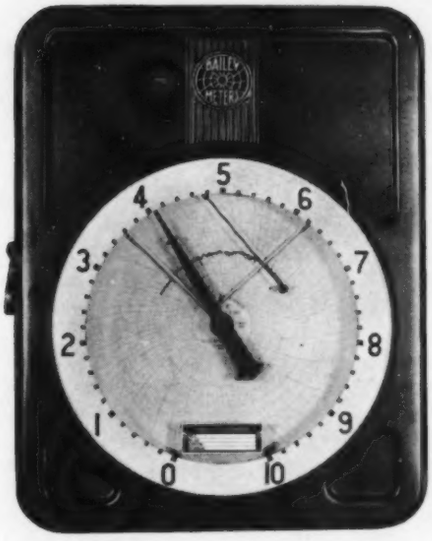

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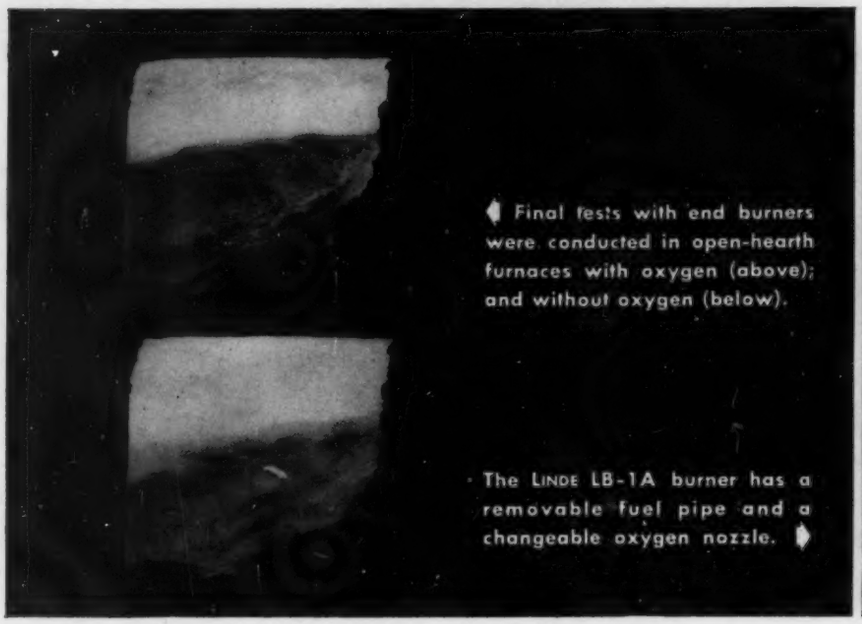
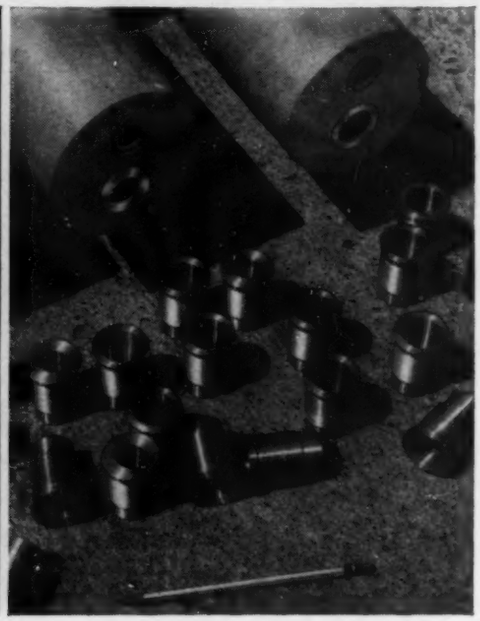
What's the Story on Oxygen in Steel-Making Furnaces? No. 4 of a Series { No. 1 was a General Review; No. 2 was on Decarburization; No. 3 was on Direct Scrap Melt-Down



Final tests with end burners were conducted in open-hearth furnaces with oxygen (above); and without oxygen (below).

The LINDE LB-1A burner has a removable fuel pipe and a changeable oxygen nozzle.



More Heat for Scrap Melting

MELT-DOWN TIME CAN BE REDUCED APPRECIABLY when oxygen is used in end-burner flames. This has been shown by the data on literally hundreds of the more than 7,500 heats on all phases of oxygen use in 34 furnace shops with which LINDE has co-operated. Increased heat input for scrap melting is obtained by introducing an oxygen stream beneath the fuel stream. Yet there is no increase in volume of combustion gases. This is particularly important in old furnaces with insufficient checker capacity.

LINDE burner developments have demonstrated the advantages of the undershot oxygen stream. This produces a much hotter flame than the conventional air-fuel burner. The oxygen-fuel flame is hottest on the underside. The upper part of the flame, near the roof, is no hotter than that produced by the conventional burner.

The design of the undershot burner is the result of many tests. Burners were designed to produce long thin flames and wide flat flames. Some were tested in full-size furnaces as end burners, others as auxiliary burners inserted through the back wall and roof.

Research on end burners is, of course, only one phase of LINDE's program. The goal is to find the most effective methods for using oxygen in steelmaking furnaces. Already this effort has resulted in a significant reduction in cubic feet of oxygen required per ton of steel to accomplish the desired production increase. In co-operation with steelmakers, LINDE will continue to explore all phases of oxygen use and report its findings as knowledge is gained.

Management and production executives are invited to write for a copy of the factual report which LINDE *has prepared on oxygen use in steel-making furnaces. This report also explains the* DRIOX *high-purity liquid oxygen system and* LINDE'S *work on low-purity gaseous oxygen. Please address Room 308, 30 East 42nd Street, New York 17, N. Y.*

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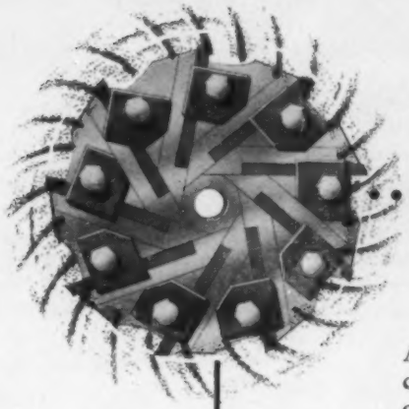

. . . These teeth slashed $892,528 from billet-conditioning costs!

A Leading Mid-Western Steel Plant using Bonnot Billeteers recently set-up a cost study program to determine the economy of machine billet chipping as compared to other conditioning methods. The study covered 24,965 tons of billets ranging in size from 4" x 4" to 8" x 8". To eliminate all possible variables billets were conditioned by each method through a range of different heats.

Results of this study showed that Billeteer conditioning cost 56% less than hand chipping, 39% less than hand scarfing. These percentages were then used to determine the savings effected during the prior five year period. For purposes of comparison, Billeteer conditioning cost was set at $1.00 per ton with basic rates for other methods being adjusted to conform with actual differentials revealed by tests. Here are the figures:

BILLETEER	714,022	$1.00	$ 714,022	———
HAND SCARFING	714,022	1.63	1,163,856	$449,834
HAND CHIPPING	714,022	2.25	1,606,550	892,528

Billeteer savings over hand scarfing were almost half a million dollars.
Billeteer savings over hand chipping were not far from one million dollars.

Here's HOW The Billeteer Cuts Conditioning Costs

INCREASES MAN-HOUR PRODUCTION . . . a single Billeteer operator can do the work of 10 hand chippers . . . and do it better.

INCREASES SCRAP RECOVERY . . . every Billeteer chip "comes clean"—classified as to analysis—ready for the charging box.

SPEEDS CRITICAL DELIVERIES . . . by permitting reclamation of bad billets and even bad heats, it facilitates maintnance of delivery schedules — reduces pick-up items at the melt shop.

INCREASES BILLET SALVAGE . . . Billeteer's low operating cost permits recovery of badly seamed billets unprofitable to salvage by other methods.

REDUCES BILLET INVENTORY . . . since otherwise "unsalvageable" billets can be saved, inventory of billets and ingots can be reduced to a minimum.

INCREASES WORKER EFFICIENCY . . . the Billeteer's 45 ton weight takes the punishment of chipping — saves workers from jitters, fatigue, and illness.

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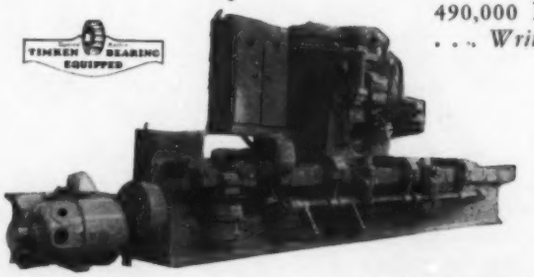

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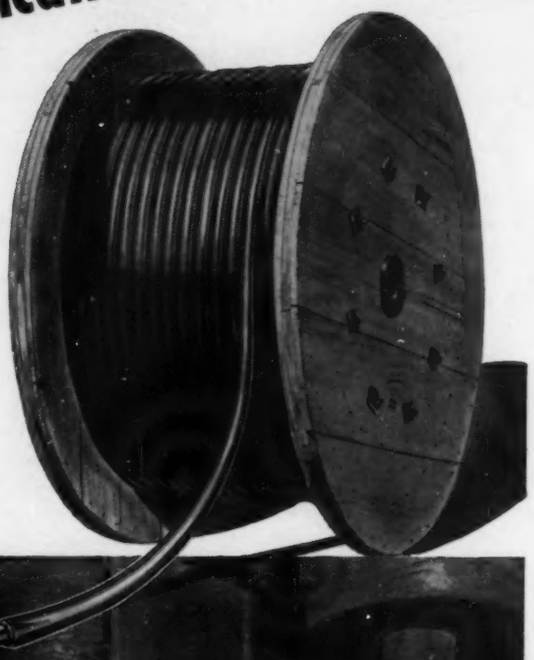

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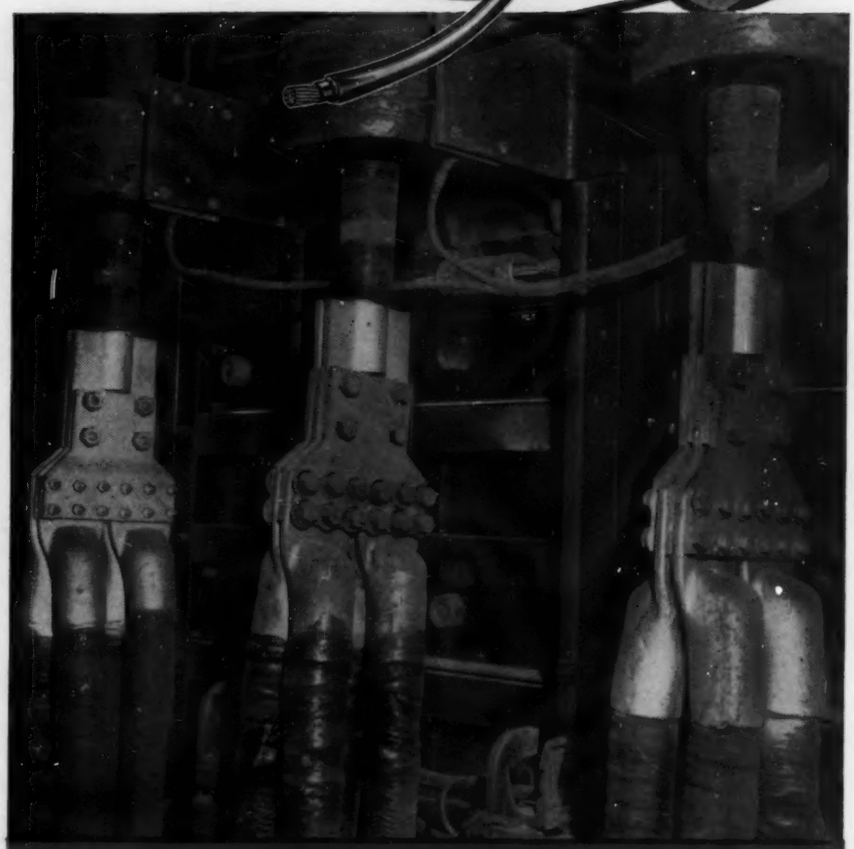

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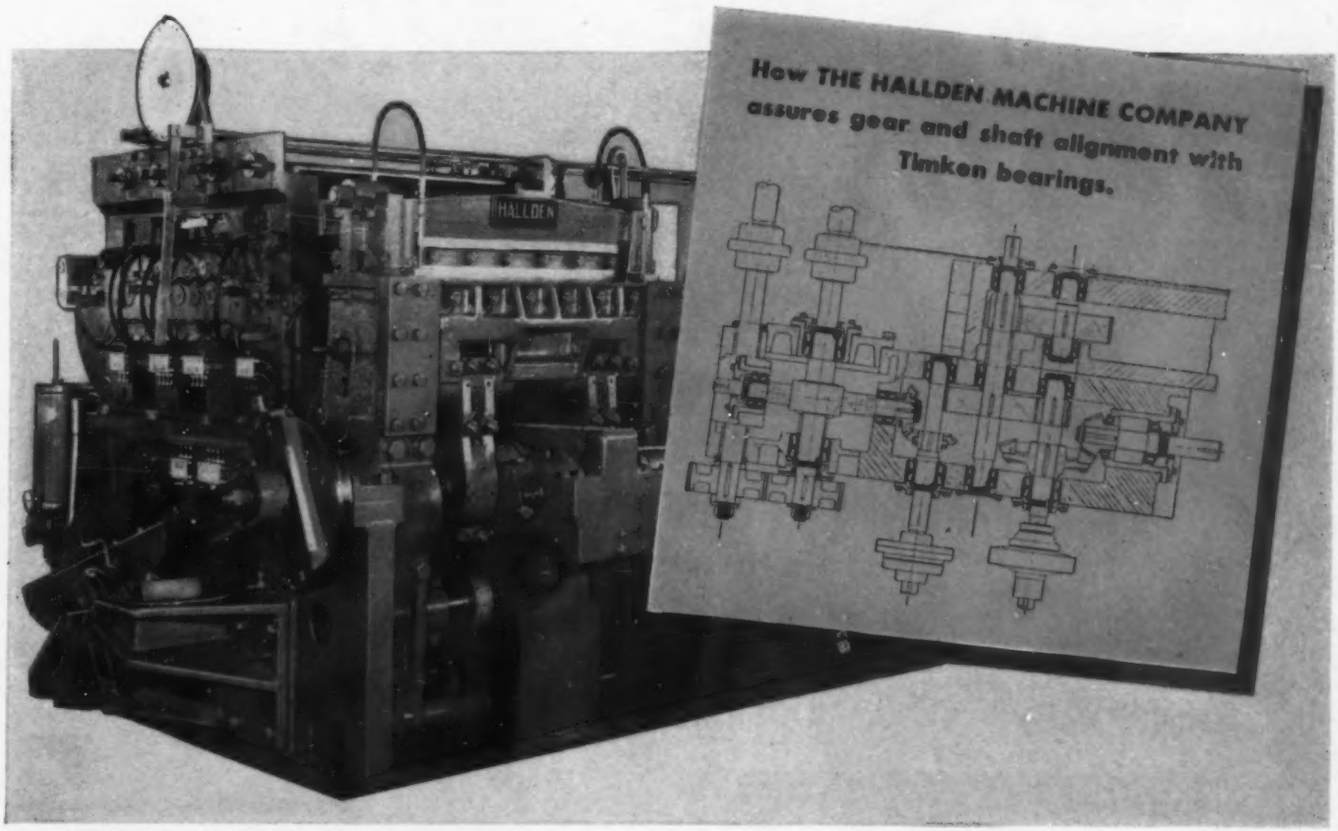

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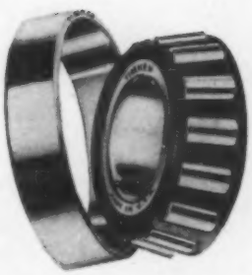

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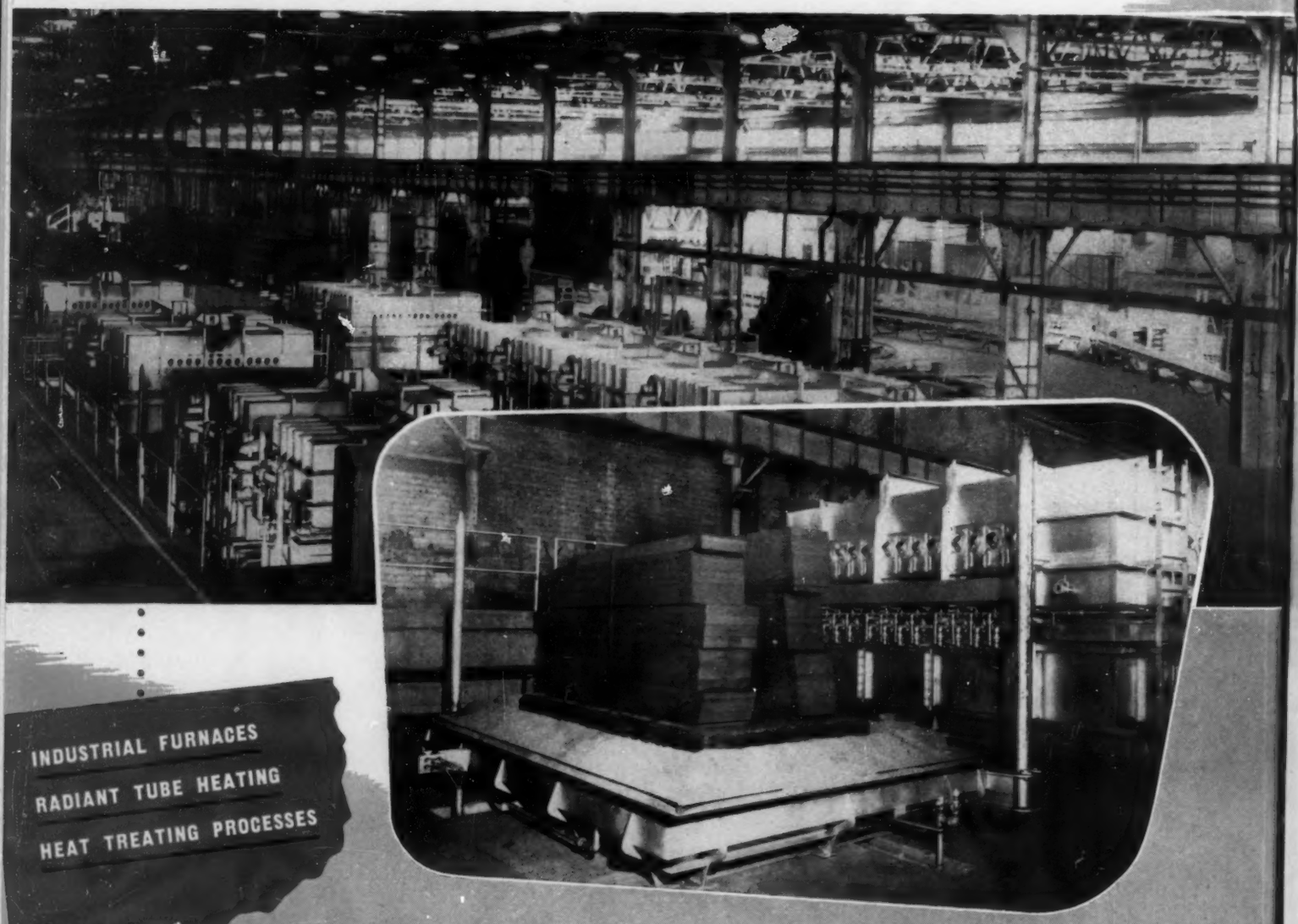

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As the white outline indicates, a standard unit of more than double the frame size would be required to do the work of Speedaire.

SPEEDAIRE cuts weight 275 lbs., takes 53% less space, saves $130

SPEEDAIRE enabled the builder of this portable mine conveyor to materially reduce the dead weight of his equipment. The speed reducer itself weighs 275 pounds less than a conventional worm gear unit of equivalent capacity. And because Speedaire occupies 53% less space, a further substantial reduction was effected in the size and weight of the base on which motor, drive and conveyor are mounted. An initial cost saving of $130 also was realized with Speedaire.

Speedaire is Cleveland's new fan-cooled worm-gear speed reducer. Because it is fan-cooled, Speedaire will do more work—will deliver up to *double the horsepower* of standard worm units of equal frame size, at usual motor speeds. It can be installed economically on many applications where other types have been used heretofore—giving you the advantages of a compact right-angle drive. Speedaire gives the same long, trouble-free service characteristic of all Clevelands.

Send for Catalog 300 for a full description. The Cleveland Worm & Gear Company, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

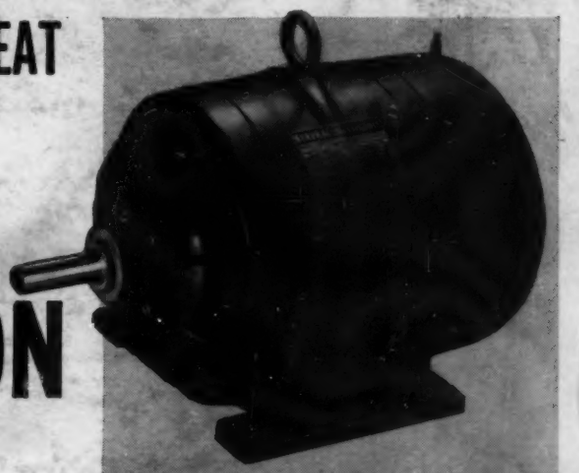
CLEVELAND
Worm Gear
Speed Reducers

4 MILLION HP CONFIRMS IT:

FOR TOUGH MOTOR JOBS, YOU CAN'T BEAT

TRI/CLAD

EXTRA PROTECTION



To date, a million and a half Tri-Clad motors, with a total output of over 4-million horsepower, have been purchased by American industry!

In every kind of plant from steel mill to dairy, these motors are proof beyond doubt that you can't beat Tri-Clad extra protection for tough motor applications. Even on jobs where special protective enclosures would ordinarily have been specified, Tri-Clad open motors, applied during the war years, have stood up to heat, dust, and dampness, operating smoothly and efficiently for years with only minimum maintenance.

Today, the Tri-Clad motor family includes many different types and sizes. But whatever your selection, the Tri-Clad motor nameplate is still your best assurance of a high return on your motor dollar. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

EXTRA PROTECTION . . . AGAINST PHYSICAL DAMAGE!

Rigid cast-iron frame and end shields protect vital motor parts from external abuse. Because they're not at the mercy of a coat of paint, they strongly resist chemical attack and dampness. Cast iron also gives you wide, nonyielding fits between end shields and frame for ease of assembly.

EXTRA PROTECTION . . . AGAINST ELECTRICAL BREAKDOWN!

Motor windings of Formex* wire, together with improved insulating materials, reduce the chances of electrical failure. Heat is dissipated quickly —motor stays young for years and years!

EXTRA PROTECTION . . . AGAINST OPERATING WEAR AND TEAR!

Bearing design affords longer life, greater capacity, improved lubrication features. Bearing seals retain lubricant, keep out dirt. One-piece, cast-aluminum rotor is practically indestructible.

*Trade-mark Reg. U.S. Pat. Off.

The toughest TRI/CLAD ever built!

Newest addition to the Tri-Clad motor family is the Tri-Clad totally enclosed, fan-cooled motor for use in adverse atmospheres. It gives you these important construction features:

- *A cast-iron, double wall frame which completely encloses and protects the windings and punchings.*
- *A nonshrinking compound around motor leads which protects motor interior from dust and moisture.*
- *A rotating labyrinth seal which further protects the motor interior from damage by foreign matter.*

In many steel plants, Tri-Clad totally enclosed, fan-cooled motors are giving superior service. They have many applications as auxiliary drives on equipment operating in adverse atmospheres. They are widely used as drives on such units as exhaust fans, furnace blowers, hydraulic pumps, lubrication pumps, and grease systems. Their extra protective enclosures allow them to stand up in dirty and hot atmospheres, to give dependable, long-life service with only routine maintenance and inspection.

Behind the unusually fine service record of these motors is the extra protection built into every Tri-Clad motor to give you better performance at lower costs.

GE

TRI/CLAD

REG. U.S. PAT. OFF.

MOTORS

- OPEN (DRIPPROOF)
- TOTALLY ENCLOSED
- EXPLOSION - PROO

GENERAL ELECTRIC

660-46